

FINAL

BEST DEMONSTRATED AVAILABLE TECHNOLOGY (BDAT)
BACKGROUND DOCUMENT FOR
K071

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EXECUTIVE SUMMARY

BDAT Treatment Standards for K071

Pursuant to section 3004(m) of the Hazardous and Solid Waste Amendments (HSWA) enacted on November 8, 1984, the Environmental Protection Agency (EPA) is establishing best demonstrated available technology (BDAT) treatment standards for the listed waste identified in 40 CFR 261.32 as K071. Compliance with these BDAT treatment standards is a prerequisite for placement of the waste in units designated as land disposal units according to 40 CFR Part 268. The effective date of these treatment standards is August 8, 1990, which reflects a two-year nationwide capacity variance.

This background document provides the Agency's rationale and technical support for selecting the constituent to be regulated in K071 waste and for developing treatment standards for that regulated constituent. The document also provides waste characterization and treatment information that serves as a basis for determining whether treatment variances may be warranted. EPA may grant a treatment variance in cases where the Agency has determined that the waste in question is more difficult to treat than the waste upon which the treatment standards have been established.

The introductory section, which appears verbatim in all the First Third background documents, summarizes the Agency's legal authority and

promulgated methodology for establishing treatment standards and discusses the petition process necessary for requesting a variance from the treatment standards. The remainder of the document presents waste-specific information--the number and locations of facilities affected by the land disposal restrictions for K071 waste, the waste-generating process, waste characterization data, the technologies used to treat the waste (or similar wastes), and available performance data, including data on which the treatment standards are based. The document also explains EPA's determination of BDAT, selection of constituents to be regulated, and calculation of treatment standards.

K071 waste is listed as "brine purification muds from the mercury cell process in chlorine production, where separately prepurified brine is not used." The Agency estimates that 14 of 20 facilities using the mercury cell process do not use prepurified brine and therefore may generate K071 waste. Chlorine producers fall under Standard Industrial Classification (SIC) Code 2812.

The Agency is regulating mercury in both nonwastewater and wastewater forms of K071 waste. (For the purpose of determining the applicability of the treatment standards, wastewaters are defined as wastes containing less than 1 percent (weight basis) total suspended solids* and less than

*The term "total suspended solids" (TSS) clarifies EPA's previously used terminology of "total solids" and "filterable solids." Specifically, total suspended solids is measured by method 209C (Total Suspended Solids Dried at 103-105°C) in Standard Methods for the Examination of Water and Wastewater, Sixteenth Edition.

1 percent (weight basis) total organic carbon (TOC). Waste not meeting this definition must comply with the treatment standards for nonwastewaters.) For K071 nonwastewater, the BDAT treatment standard is based on performance data from acid leaching followed by chemical oxidation and then sludge dewatering/acid washing. For K071 wastewater, the treatment standard is based on performance data from chemical precipitation and filtration.

The following table presents the BDAT treatment standards for K071 waste. The treatment standard for nonwastewater reflects the concentration of mercury in the leachate from the Toxicity Characteristic Leaching Procedure (TCLP). For wastewater, the treatment standard reflects total mercury concentration. The units for both total concentration and TCLP leachate concentration are mg/l (parts per million on a weight-by-volume basis). Note that if the concentrations of the regulated constituents in K071 waste, as generated, are lower than or equal to the proposed BDAT treatment standards, then treatment is not required prior to land disposal.

Testing procedures are specifically identified in Appendix B of this background document.

BDAT Treatment Standards for K071

Constituent	Maximum for any single grab sample		
	Nonwastewater		Wastewater
	Total concentration (mg/kg)	TCLP leachate concentration (mg/l)	Total waste concentration (mg/l)
Mercury	NA	0.025	0.030

NA = Not applicable.

1. INTRODUCTION

This section of the background document presents a summary of the legal authority pursuant to which the best demonstrated available technology (BDAT) treatment standards were developed, a summary of EPA's promulgated methodology for developing the BDAT treatment standards, and, finally, a discussion of the petition process that should be followed to request a variance from the BDAT treatment standards.

1.1 Legal Background

1.1.1 Requirements Under HSWA

The Hazardous and Solid Waste Amendments of 1984 (HSWA), which were enacted on November 8, 1984, and which amended the Resource Conservation and Recovery Act of 1976 (RCRA), impose substantial new responsibilities on those who handle hazardous waste. In particular, the amendments require the Agency to promulgate regulations that restrict the land disposal of untreated hazardous wastes. In its enactment of HSWA, Congress stated explicitly that "reliance on land disposal should be minimized or eliminated, and land disposal, particularly landfill and surface impoundment, should be the least favored method for managing hazardous wastes" (RCRA section 1002(b)(7), 42 U.S.C. 6901(b)(7)).

One part of the amendments specifies dates on which particular groups of untreated hazardous wastes will be prohibited from land disposal unless "it has been demonstrated to the Administrator, to a reasonable degree of certainty, that there will be no migration of hazardous

constituents from the disposal unit or injection zone for as long as the wastes remain hazardous" (RCRA section 3004(d)(1), (e)(1), (g)(5), 42 U.S.C. 6924 (d)(1), (e)(1), (g)(5)).

For the purpose of the restrictions, HSWA defines land disposal "to include, but not be limited to, any placement of . . . hazardous waste in a landfill, surface impoundment, waste pile, injection well, land treatment facility, salt dome formation, salt bed formation, or underground mine or cave" (RCRA section 3004(k), 42 U.S.C. 6924(k)). Although HSWA defines land disposal to include injection wells, such disposal of solvents, dioxins, and certain other wastes, known as the California List wastes, is covered on a separate schedule (RCRA section 3004(f)(2), 42 U.S.C. 6924 (f)(2)). This schedule requires that EPA develop land disposal restrictions for deep well injection by August 8, 1988.

The amendments also require the Agency to set "levels or methods of treatment, if any, which substantially diminish the toxicity of the waste or substantially reduce the likelihood of migration of hazardous constituents from the waste so that short-term and long-term threats to human health and the environment are minimized" (RCRA section 3004(m)(1), 42 U.S.C. 6924 (m)(1)). Wastes that satisfy such levels or methods of treatment established by EPA, i.e., treatment standards, are not prohibited from being land disposed.

In setting treatment standards for listed or characteristic wastes, EPA may establish different standards for particular wastes within a single waste code with differing treatability characteristics. One such

characteristic is the physical form of the waste. This frequently leads to different standards for wastewaters and nonwastewaters.

Alternatively, EPA can establish a treatment standard that is applicable to more than one waste code when, in EPA's judgment, a particular constituent present in the wastes can be treated to the same concentration in all the wastes.

In those instances where a generator can demonstrate that the standard promulgated for the generator's waste cannot be achieved, the amendments allow the Agency to grant a variance from a treatment standard by revising the treatment standard for that particular waste through rulemaking procedures. (A further discussion of treatment variances is provided in Section 1.3.)

The land disposal restrictions are effective when promulgated unless the Administrator grants a national variance and establishes a different date (not to exceed 2 years beyond the statutory deadline) based on "the earliest date on which adequate alternative treatment, recovery, or disposal capacity which protects human health and the environment will be available" (RCRA section 3004(h)(2), 42 U.S.C. 6924 (h)(2)).

If EPA fails to set treatment standards by the statutory deadline for any hazardous waste in the First Third or Second Third waste groups (see Section 1.1.2), the waste may not be disposed in a landfill or surface impoundment unless the facility is in compliance with the minimum technological requirements specified in section 3004(o) of RCRA. In

addition, prior to disposal, the generator must certify to the Administrator that the availability of treatment capacity has been investigated, and it has been determined that disposal in a landfill or surface impoundment is the only practical alternative to treatment currently available to the generator. This restriction on the use of landfills and surface impoundments applies until EPA sets treatment standards for the waste or until May 8, 1990, whichever is sooner. If the Agency fails to set treatment standards for any ranked hazardous waste by May 8, 1990, the waste is automatically prohibited from land disposal unless the waste is placed in a land disposal unit that is the subject of a successful "no migration" demonstration (RCRA section 3004(g), 42 U.S.C. 6924(g)). "No migration" demonstrations are based on case-specific petitions that show there will be no migration of hazardous constituents from the unit for as long as the waste remains hazardous.

1.1.2 Schedule for Developing Restrictions

Under section 3004(g) of RCRA, EPA was required to establish a schedule for developing treatment standards for all wastes that the Agency had listed as hazardous by November 8, 1984. Section 3004(g) required that this schedule consider the intrinsic hazards and volumes associated with each of these wastes. The statute required EPA to set treatment standards according to the following schedule:

1. Solvent and dioxin wastes by November 8, 1986;
2. The "California List" wastes by July 8, 1987;
3. At least one-third of all listed hazardous wastes by August 8, 1988 (First Third);

4. At least two-thirds of all listed hazardous wastes by June 8, 1989 (Second Third); and
5. All remaining listed hazardous wastes and all hazardous wastes identified as of November 8, 1984, by one or more of the characteristics defined in 40 CFR Part 261 by May 8, 1990 (Third Third).

The statute specifically identified the solvent wastes as those covered under waste codes F001, F002, F003, F004, and F005; it identified the dioxin-containing hazardous wastes as those covered under waste codes F020, F021, F022, and F023.

Wastes collectively known as the California List wastes, defined under section 3004(d) of HSWA, are liquid hazardous wastes containing metals, free cyanides, PCBs, corrosives (i.e., a pH less than or equal to 2.0), and any liquid or nonliquid hazardous waste containing halogenated organic compounds (HOCs) above 0.1 percent by weight. Rules for the California List were proposed on December 11, 1986, and final rules for PCBs, corrosives, and HOC-containing wastes were established August 12, 1987. In that rule, EPA elected not to establish treatment standards for metals. Therefore, the statutory limits became effective.

On May 28, 1986, EPA published a final rule (51 FR 19300) that delineated the specific waste codes that would be addressed by the First Third, Second Third, and Third Third land disposal restriction rules. This schedule is incorporated into 40 CFR 268.10, 268.11, and 268.12.

1.2 Summary of Promulgated BDAT Methodology

In a November 7, 1986, rulemaking, EPA promulgated a technology-based approach to establishing treatment standards under section 3004(m).

Congress indicated in the legislative history accompanying the HSWA that "[t]he requisite levels of [sic] methods of treatment established by the Agency should be the best that has been demonstrated to be achievable," noting that the intent is "to require utilization of available technology" and not a "process which contemplates technology-forcing standards" (Vol. 130 Cong. Rec. S9178 (daily ed., July 25, 1984)). EPA has interpreted this legislative history as suggesting that Congress considered the requirement under section 3004(m) to be met by application of the best demonstrated and achievable (i.e., available) technology prior to land disposal of wastes or treatment residuals. Accordingly, EPA's treatment standards are generally based on the performance of the best demonstrated available technology (BDAT) identified for treatment of the hazardous constituents. This approach involves the identification of potential treatment systems, the determination of whether they are demonstrated and available, and the collection of treatment data from well-designed and well-operated systems.

The treatment standards, according to the statute, can represent levels or methods of treatment, if any, that substantially diminish the toxicity of the waste or substantially reduce the likelihood of migration of hazardous constituents. Wherever possible, the Agency prefers to establish BDAT treatment standards as "levels" of treatment (i.e., performance standards), rather than to require the use of specific treatment "methods." EPA believes that concentration-based treatment

levels offer the regulated community greater flexibility to develop and implement compliance strategies, as well as an incentive to develop innovative technologies.

1.2.1 Waste Treatability Group

In developing the treatment standards, EPA first characterizes the waste(s). As necessary, EPA may establish treatability groups for wastes having similar physical and chemical properties. That is, if EPA believes that hazardous constituents in wastes represented by different waste codes could be treated to similar concentrations using identical technologies, the Agency combines the wastes into one treatability group. EPA generally considers wastes to be similar when they are both generated from the same industry and from similar processing stages. In addition, EPA may combine two or more separate wastes into the same treatability group when data are available showing that the waste characteristics affecting performance are similar or that one of the wastes in the group, the waste from which treatment standards are to be developed, is expected to be most difficult to treat.

Once the treatability groups have been established, EPA collects and analyzes data on identified technologies used to treat the wastes in each treatability group. The technologies evaluated must be demonstrated on the waste or a similar waste and must be available for use.

1.2.2 Demonstrated and Available Treatment Technologies

Consistent with legislative history, EPA considers demonstrated technologies to be those that are currently used on a full-scale basis to

treat the waste of interest or a waste judged to be similar (see 51 FR 40588, November 7, 1986). EPA also will consider as demonstrated treatment those technologies used to separate or otherwise process chemicals and other materials on a full-scale basis. Some of these technologies clearly are applicable to waste treatment, since the wastes are similar to raw materials processed in industrial applications.

For most of the waste treatability groups for which EPA will promulgate treatment standards, EPA will identify demonstrated technologies either through review of literature related to current waste treatment practices or on the basis of information provided by specific facilities currently treating the waste or similar wastes.

In cases where the Agency does not identify any facilities treating wastes represented by a particular waste treatability group, EPA may transfer a finding of demonstrated treatment. To do this, EPA will compare the parameters affecting treatment selection for the waste treatability group of interest to other wastes for which demonstrated technologies already have been determined. (The parameters affecting treatment selection and their use for this waste are described in Section 3.2 of this document.) If the parameters affecting treatment selection are similar, then the Agency will consider the treatment technology also to be demonstrated for the waste of interest. For example, EPA considers rotary kiln incineration to be a demonstrated technology for many waste codes containing hazardous organic

constituents, high total organic content, and high filterable solids content, regardless of whether any facility is currently treating these wastes. The basis for this determination is data found in literature and data generated by EPA confirming the use of rotary kiln incineration on wastes having the above characteristics.

If no full-scale treatment or recovery operations are identified for a waste or wastes with similar physical or chemical characteristics that affect treatment selection, the Agency will be unable to identify any demonstrated treatment technologies for the waste, and, accordingly, the waste will be prohibited from land disposal (unless handled in accordance with the exemption and variance provisions of the rule). The Agency is, however, committed to establishing treatment standards as soon as new or improved treatment processes are demonstrated (and available).

Operations only available at research facilities, pilot- and bench-scale operations, will not be considered in identifying demonstrated treatment technologies for a waste. Nevertheless, EPA may use data generated at research facilities in assessing the performance of demonstrated technologies.

As discussed earlier, Congress intended that technologies used to establish treatment standards under section 3004(m) be not only "demonstrated," but also "available." To decide whether demonstrated technologies may be considered "available," the Agency determines whether they (1) are commercially available and (2) substantially diminish the

toxicity of the waste or substantially reduce the likelihood of migration of hazardous constituents from the waste. These criteria are discussed below.

1. Commercially available treatment. If the demonstrated treatment technology is a proprietary or patented process that is not generally available, EPA will not consider the technology in its determination of the treatment standards. EPA will consider proprietary or patented processes available if it determines that the treatment method can be purchased or licensed from the proprietor or is a commercially available treatment. The services of the commercial facility offering this technology often can be purchased even if the technology itself cannot be purchased.
2. Substantial treatment. To be considered "available," a demonstrated treatment technology must "substantially diminish the toxicity" of the waste or "substantially reduce the likelihood of migration of hazardous constituents" from the waste in accordance with section 3004(m). By requiring that substantial treatment be achieved in order to set a treatment standard, the statute ensures that all wastes are adequately treated before being placed in or on the land and ensures that the Agency does not require a treatment method that provides little or no environmental benefit. Treatment will always be deemed substantial if it results in nondetectable levels of the hazardous constituents of concern (provided the nondetectable levels are low relative to the concentrations in the untreated waste). If nondetectable levels are not achieved, then a determination of substantial treatment will be made on a case-by-case basis. This approach is necessary because of the difficulty of establishing a meaningful guideline that can be applied broadly to the many wastes and technologies to be considered. EPA will consider the following factors in an effort to evaluate whether a technology provides substantial treatment on a case-by-case basis:
 - Number and types of constituents treated;
 - Performance (concentration of the constituents in the treatment residuals); and
 - Percent of constituents removed.

EPA will only set treatment standards based on a technology that meets both availability criteria. Thus, the decision to classify a technology as "unavailable" will have a direct impact on the treatment standard. If the best demonstrated technology is unavailable, the treatment standards will be based on the next best demonstrated treatment technology determined to be available. To the extent that the resulting treatment standards are less stringent, greater concentrations of hazardous constituents in the treatment residuals could be placed in land disposal units.

There also may be circumstances in which EPA concludes that for a given waste none of the demonstrated treatment technologies are "available" for purposes of establishing the 3004(m) treatment performance standards. Subsequently, these wastes will be prohibited from continued placement in or on the land unless managed in accordance with applicable exemptions and variance provisions. The Agency is, however, committed to establishing new treatment standards as soon as new or improved treatment processes become available.

1.2.3 Collection of Performance Data

Performance data on the demonstrated available technologies are evaluated by the Agency to determine whether the data are representative of well-designed and well-operated treatment systems. Only data from well-designed and well-operated systems are considered in determining BDAT. The data evaluation includes data already collected directly by

EPA and/or data provided by industry. In those instances where additional data are needed to supplement existing information, EPA collects additional data through a sampling and analysis program. The principal elements of this data collection program are: (1) the identification of facilities for site visits, (2) the engineering site visit, (3) the sampling and analysis plan, (4) the sampling visit, and (5) the onsite engineering report.

(1) Identification of facilities for site visits. To identify facilities that generate and/or treat the waste of concern, EPA uses a number of information sources. These include Stanford Research Institute's Directory of Chemical Producers; EPA's Hazardous Waste Data Management System (HWDMS); the 1986 Treatment, Storage, Disposal Facility (TSDF) National Screening Survey; and EPA's Industry Studies Data Base. In addition, EPA contacts trade associations to inform them that the Agency is considering visits to facilities in their industry and to solicit their assistance in identifying facilities for EPA to consider in its treatment sampling program.

After identifying facilities that treat the waste, EPA uses this hierarchy to select sites for engineering visits: (1) generators treating single wastes on site; (2) generators treating multiple wastes together on site; (3) commercial treatment, storage, and disposal facilities (TSDFs); and (4) EPA in-house treatment. This hierarchy is based on two concepts: (1) to the extent possible, EPA should develop treatment

standards from data produced by treatment facilities handling only a single waste, and (2) facilities that routinely treat a specific waste have had the best opportunity to optimize design parameters. Although excellent treatment can occur at many facilities that are not high in this hierarchy, EPA has adopted this approach to avoid, when possible, ambiguities related to the mixing of wastes before and during treatment.

When possible, the Agency will evaluate treatment technologies using full-scale treatment systems. If performance data from properly designed and operated full-scale systems treating a particular waste or a waste judged to be similar are not available, EPA may use data from research facility operations. Whenever research facility data are used, EPA will explain in the preamble and background document why such data were used and will request comments on the use of such data.

Although EPA's data bases provide information on treatment for individual wastes, the data bases rarely provide data that support the selection of one facility for sampling over another. In cases where several treatment sites appear to fall into the same level of the hierarchy, EPA selects sites for visits strictly on the basis of which facility could most expeditiously be visited and later sampled if justified by the engineering visit.

(2) Engineering site visit. Once a treatment facility has been selected, an engineering site visit is made to confirm that a candidate for sampling meets EPA's criteria for a well-designed facility and to

ensure that the necessary sampling points can be accessed to determine operating parameters and treatment effectiveness. During the visit, EPA also confirms that the facility appears to be well operated, although the actual operation of the treatment system during sampling is the basis for EPA's decisions regarding proper operation of the treatment unit. In general, the Agency considers a well-designed facility to be one that contains the unit operations necessary to treat the various hazardous constituents of the waste, as well as to control other nonhazardous materials in the waste that may affect treatment performance.

In addition to ensuring that a system is reasonably well designed, the engineering visit examines whether the facility has a way to measure the operating parameters that affect performance of the treatment system during the waste treatment period. For example, EPA may choose not to sample a treatment system that operates in a continuous mode, for which an important operating parameter cannot be continuously recorded. In such systems, instrumentation is important in determining whether the treatment system is operating at design values during the waste treatment period.

(3) Sampling and analysis plan. If after the engineering site visit the Agency decides to sample a particular plant, the Agency will then develop a site-specific sampling and analysis plan (SAP) according to the Generic Quality Assurance Project Plan for the Land Disposal Restrictions Program ("BDAT"), EPA/530-SW-87-011. In brief, the SAP discusses where the Agency plans to sample, how the samples will be taken, the frequency

of sampling, the constituents to be analyzed and the method of analysis, operational parameters to be obtained, and specific laboratory quality control checks on the analytical results.

The Agency will generally produce a draft of the site-specific SAP within 2 to 3 weeks of the engineering visit. The draft of the SAP is then sent to the plant for review and comment. With few exceptions, the draft SAP should be a confirmation of data collection activities discussed with the plant personnel during the engineering site visit. EPA encourages plant personnel to recommend any modifications to the SAP that they believe will improve the quality of the data.

It is important to note that sampling of a plant by EPA does not mean that the data will be used in the development of BDAT treatment standards. EPA's final decision on whether to use data from a sampled plant depends on the actual analysis of the waste being treated and on the operating conditions at the time of sampling. Although EPA would not plan to sample a facility that was not ostensibly well designed and well operated, there is no way to ensure that at the time of the sampling the facility will not experience operating problems. Additionally, EPA statistically compares its test data to suitable industry-provided data, where available, in its determination of what data to use in developing treatment standards. The methodology for comparing data is presented later in this section.

(Note: Facilities wishing to submit data for consideration in the development of BDAT standards should, to the extent possible, provide sampling information similar to that acquired by EPA. Such facilities should review the Generic Quality Assurance Project Plan for the Land Disposal Restrictions Program ("BDAT"), which delineates all of the quality control and quality assurance measures associated with sampling and analysis. Quality assurance and quality control procedures are summarized in Section 1.2.6 of this document.)

(4) Sampling visit. The purpose of the sampling visit is to collect samples that characterize the performance of the treatment system and to document the operating conditions that existed during the waste treatment period. At a minimum, the Agency attempts to collect sufficient samples of the untreated waste and solid and liquid treatment residuals so that variability in the treatment process can be accounted for in the development of the treatment standards. To the extent practicable, and within safety constraints, EPA or its contractors collect all samples and ensure that chain-of-custody procedures are conducted so that the integrity of the data is maintained.

In general, the samples collected during the sampling visit will have already been specified in the SAP. In some instances, however, EPA will not be able to collect all planned samples because of changes in the facility operation or plant upsets; EPA will explain any such deviations from the SAP in its follow-up onsite engineering report.

(5) Onsite engineering report. EPA summarizes all its data collection activities and associated analytical results for testing at a facility in a report referred to as the onsite engineering report (OER). This report characterizes the waste(s) treated, the treated residual concentrations, the design and operating data, and all analytical results including methods used and accuracy results. This report also describes any deviations from EPA's suggested analytical methods for hazardous wastes that appear in Test Methods for Evaluating Solid Waste, SW-846, Third Edition, November 1986.

After the OER is completed, the report is submitted to the waste generator and/or treater for review. This review provides a final opportunity for claiming any information contained in the report as confidential. Following the review and incorporation of comments, as appropriate, the report is made available to the public with the exception of any material claimed as confidential.

1.2.4 Hazardous Constituents Considered and Selected for Regulation

(1) Development of BDAT list. The list of hazardous constituents within the waste codes that are targeted for treatment is referred to by the Agency as the BDAT constituent list. This list, provided as Table 1-1, is derived from the constituents presented in 40 CFR Part 261, Appendices VII and VIII, as well as several ignitable constituents used as the basis of listing wastes as F003 and F005. These sources provide a

Table 1-1 BDAT Constituent List

BDAT reference no.	Constituent	CAS no.
<u>Volatile organics</u>		
222.	Acetone	67-64-1
1.	Acetonitrile	75-05-8
2.	Acrolein	107-02-8
3.	Acrylonitrile	107-13-1
4.	Benzene	71-43-2
5.	Bromodichloromethane	75-27-4
6.	Bromomethane	74-83-9
223.	n-Butyl alcohol	71-36-3
7.	Carbon tetrachloride	56-23-5
8.	Carbon disulfide	75-15-0
9.	Chlorobenzene	108-90-7
10.	2-Chloro-1,3-butadiene	126-99-8
11.	Chlorodibromomethane	124-48-1
12.	Chloroethane	75-00-3
13.	2-Chloroethyl vinyl ether	110-75-8
14.	Chloroform	67-66-3
15.	Chloromethane	74-87-3
16.	3-Chloropropene	107-05-1
17.	1,2-Dibromo-3-chloropropane	96-12-8
18.	1,2-Dibromoethane	106-93-4
19.	Dibromomethane	74-95-3
20.	trans-1,4-Dichloro-2-butene	110-57-6
21.	Dichlorodifluoromethane	75-71-8
22.	1,1-Dichloroethane	75-34-3
23.	1,2-Dichloroethane	107-06-2
24.	1,1-Dichloroethylene	75-35-4
25.	trans-1,2-Dichloroethene	156-60-5
26.	1,2-Dichloropropane	78-87-5
27.	trans-1,3-Dichloropropene	10061-02-6
28.	cis-1,3-Dichloropropene	10061-01-5
29.	1,4-Dioxane	123-91-1
224.	2-Ethoxyethanol	110-80-5
225.	Ethyl acetate	141-78-6
226.	Ethyl benzene	100-41-4
30.	Ethyl cyanide	107-12-0
227.	Ethyl ether	60-29-7
31.	Ethyl methacrylate	97-63-2
214.	Ethylene oxide	75-21-8
32.	Iodomethane	74-88-4
33.	Isobutyl alcohol	78-83-1
228.	Methanol	67-56-1
34.	Methyl ethyl ketone	78-93-3

Table 1-1 (Continued)

BOAI reference no.	Constituent	CAS no.
<u>Volatile organics (continued)</u>		
229.	Methyl isobutyl ketone	108-10-1
35.	Methyl methacrylate	80-62-6
37.	Methacrylonitrile	126-98-7
38.	Methylene chloride	75-09-2
230.	2-Nitropropane	79-46-9
39.	Pyridine	110-86-1
40.	1,1,1,2-Tetrachloroethane	630-20-6
41.	1,1,2,2-Tetrachloroethane	79-34-6
42.	Tetrachloroethene	127-18-4
43.	Toluene	108-88-3
44.	Tribromomethane	75-25-2
45.	1,1,1-Trichloroethane	71-55-6
46.	1,1,2-Trichloroethane	79-00-5
47.	Trichloroethene	79-01-6
48.	Trichloromonofluoromethane	75-69-4
49.	1,2,3-Trichloropropane	96-18-4
231.	1,1,2-Trichloro-1,2,2-trifluoro-ethane	76-13-1
50.	Vinyl chloride	75-01-4
215.	1,2-Xylene	97-47-6
216.	1,3-Xylene	108-38-3
217.	1,4 Xylene	106-44-5
<u>Semivolatile organics</u>		
51.	Acenaphthalene	208-96-8
52.	Acenaphthene	83-32-9
53.	Acetophenone	96-86-2
54.	2-Acetylaminofluorene	53-96-3
55.	4-Aminobiphenyl	92-67-1
56.	Aniline	62-53-3
57.	Anthracene	120-12-7
58.	Aramite	140-57-8
59.	Benz(a)anthracene	56-55-3
218.	Benzal chloride	98-87-3
60.	Benzenethiol	108-98-5
61.	Deleted	
62.	Benzo(a)pyrene	50-32-8
63.	Benzo(b)fluoranthene	205-99-2
64.	Benzo(ghi)perylene	191-24-2
65.	Benzo(k)fluoranthene	207-08-9
66.	p-Benzoquinone	106-51-4

Table 1-1 (Continued)

BDAI reference no.	Constituent	CAS no.
<u>Semivolatile organics (continued)</u>		
67.	Bis(2-chloroethoxy)methane	111-91-1
68.	Bis(2-chloroethyl)ether	111-44-4
69.	Bis(2-chloroisopropyl)ether	39638-32-9
70.	Bis(2-ethylhexyl)phthalate	117-81-7
71.	4-Bromophenyl phenyl ether	101-55-3
72.	Butyl benzyl phthalate	85-68-7
73.	2-sec-Butyl-4,6-dinitrophenol	88-85-7
74.	p-Chloroaniline	106-47-8
75.	Chlorobenzilate	510-15-6
76.	p-Chloro-m-cresol	59-50-7
77.	2-Chloronaphthalene	91-58-7
78.	2-Chlorophenol	95-57-8
79.	3-Chloropropionitrile	542-76-7
80.	Chrysene	218-01-9
81.	ortho-Cresol	95-48-7
82.	para-Cresol	106-44-5
232.	Cyclohexanone	108-94-1
83.	Dibenz(a,h)anthracene	53-70-3
84.	Dibenzo(a,e)pyrene	192-65-4
85.	Dibenzo(a,i)pyrene	189-55-9
86.	m-Dichlorobenzene	541-73-1
87.	o-Dichlorobenzene	95-50-1
88.	p-Dichlorobenzene	106-46-7
89.	3,3'-Dichlorobenzidine	91-94-1
90.	2,4-Dichlorophenol	120-83-2
91.	2,6-Dichlorophenol	87-65-0
92.	Diethyl phthalate	84-66-2
93.	3,3'-Dimethoxybenzidine	119-90-4
94.	p-Dimethylaminoazobenzene	60-11-7
95.	3,3'-Dimethylbenzidine	119-93-7
96.	2,4-Dimethylphenol	105-67-9
97.	Dimethyl phthalate	131-11-3
98.	Di-n-butyl phthalate	84-74-2
99.	1,4-Dinitrobenzene	100-25-4
100.	4,6-Dinitro-o-cresol	534-52-1
101.	2,4-Dinitrophenol	51-28-5
102.	2,4-Dinitrotoluene	121-14-2
103.	2,6-Dinitrotoluene	606-20-2
104.	Di-n-octyl phthalate	117-84-0
105.	Di-n-propylnitrosamine	621-64-7
106.	Diphenylamine	122-39-4
219.	Diphenylnitrosamine	86-30-6

Table 1-1 (Continued)

BDAI reference no.	Constituent	CAS no.
<u>Semivolatile organics (continued)</u>		
107.	1,2-Diphenylhydrazine	122-66-7
108.	Fluoranthene	206-44-0
109.	Fluorene	86-73-7
110.	Hexachlorobenzene	118-74-1
111.	Hexachlorobutadiene	87-68-3
112.	Hexachlorocyclopentadiene	77-47-4
113.	Hexachloroethane	67-72-1
114.	Hexachlorophene	70-30-4
115.	Hexachloropropene	1888-71-7
116.	Indeno(1,2,3-cd)pyrene	193-39-5
117.	Isosafrole	120-58-1
118.	Methapyriline	91-80-5
119.	3-Methylcholanthrene	56-49-5
120.	4,4'-Methylenebis (2-chloroaniline)	101-14-4
36.	Methyl methanesulfonate	66-27-3
121.	Naphthalene	91-20-3
122.	1,4-Naphthoquinone	130-15-4
123.	1-Naphthylamine	134-32-7
124.	2-Naphthylamine	91-59-8
125.	p-Nitroaniline	100-01-6
126.	Nitrobenzene	98-95-3
127.	4-Nitrophenol	100-02-7
128.	N-Nitrosodi-n-butylamine	924-16-3
129.	N-Nitrosodiethylamine	55-18-5
130.	N-Nitrosodimethylamine	62-75-9
131.	N-Nitrosomethylethylamine	10595-95-6
132.	N-Nitrosomorpholine	59-89-2
133.	N-Nitrosopiperidine	100-75-4
134.	N-Nitrosopyrrolidine	930-55-2
135.	5-Nitro-o-toluidine	99-65-8
136.	Pentachlorobenzene	608-93-5
137.	Pentachloroethane	76-01-7
138.	Pentachloronitrobenzene	82-68-8
139.	Pentachlorophenol	87-86-5
140.	Phenacetin	62-44-2
141.	Phenanthrene	85-01-8
142.	Phenol	108-95-2
220.	Phthalic anhydride	85-44-9
143.	2-Picoline	109-06-8
144.	Pronamide	23950-58-5
145.	Pyrene	129-00-0
146.	Resorcinol	108-46-3

Table 1.1 (Continued)

BDAT reference no.	Constituent	CAS no.
<u>Semivolatile organics (continued)</u>		
147.	Safrole	94-59-7
148.	1,2,4,5-Tetrachlorobenzene	95-94-3
149.	2,3,4,6-Tetrachlorophenol	58-90-2
150.	1,2,4-Trichlorobenzene	120-82-1
151.	2,4,5-Trichlorophenol	95-95-4
152.	2,4,6-Trichlorophenol	88-06-2
153.	Tris(2,3-dibromopropyl) phosphate	126-72-7
<u>Metals</u>		
154.	Antimony	7440-36-0
155.	Arsenic	7440-38-2
156.	Barium	7440-39-3
157.	Beryllium	7440-41-7
158.	Cadmium	7440-43-9
159.	Chromium (total)	7440-47-3
221.	Chromium (hexavalent)	-
160.	Copper	7440-50-8
161.	Lead	7439-92-1
162.	Mercury	7439-97-6
163.	Nickel	7440-02-0
164.	Selenium	7782-49-2
165.	Silver	7440-22-4
166.	Thallium	7440-28-0
167.	Vanadium	7440-62-2
168.	Zinc	7440-66-6
<u>Inorganics other than metals</u>		
169.	Cyanide	57-12-5
170.	Fluoride	16964-48-8
171.	Sulfide	8496-25-8
<u>Organochlorine pesticides</u>		
172.	Aldrin	309-00-2
173.	alpha-BHC	319-84-6
174.	beta-BHC	319-85-7
175.	delta-BHC	319-86-8

Table 1-1 (Continued)

BDAT reference no.	Constituent	CAS no.
<u>Organochlorine pesticides (continued)</u>		
176.	gamma-BHC	58-89-9
177.	Chlordane	57-74-9
178.	DDD	72-54-8
179.	DDC	72-55-9
180.	DDT	50-29-3
181.	Dieldrin	60-57-1
182.	Endosulfan I	939-98-8
183.	Endosulfan II	33213-6-5
184.	Endrin	72-20-8
185.	Endrin aldehyde	7421-93-4
186.	Heptachlor	76-44-8
187.	Heptachlor epoxide	1024-57-3
188.	Isodrin	465-73-6
189.	Kepone	143-50-0
190.	Methoxychlor	72-43-5
191.	Toxaphene	8001-35-2
<u>Phenoxyacetic acid herbicides</u>		
192.	2,4-Dichlorophenoxyacetic acid	94-75-7
193.	Silvex	93-72-1
194.	2,4,5-T	93-76-5
<u>Organophosphorous insecticides</u>		
195.	Disulfoton	298-04-4
196.	Famphur	52-85-7
197.	Methyl parathion	298-00-0
198.	Parathion	56-38-2
199.	Phorate	298-02-2
<u>PCBs</u>		
200.	Aroclor 1016	12674-11-2
201.	Aroclor 1221	11104-28-2
202.	Aroclor 1232	11141-16-5
203.	Aroclor 1242	53469-21-9
204.	Aroclor 1248	12672-29-6
205.	Aroclor 1254	11097-69-1
206.	Aroclor 1260	11096-82-5

Table 1-1 (Continued)

BDAT reference no.	Constituent	CAS no.
<u>Dioxins and furans</u>		
207.	Hexachlorodibenzo-p-dioxins	-
208.	Hexachlorodibenzofurans	-
209.	Pentachlorodibenzo-p-dioxins	-
210.	Pentachlorodibenzofurans	-
211.	Tetrachlorodibenzo-p-dioxins	-
212.	Tetrachlorodibenzofurans	-
213.	2,3,7,8-tetrachlorodibenzo-p-dioxin	1746-01-6

comprehensive list of hazardous constituents specifically regulated under RCRA. The BDAT list consists of those constituents that can be analyzed using methods published in SW-846, Third Edition.

The initial BDAT constituent list was published in EPA's Generic Quality Assurance Project Plan for Land Disposal Restrictions Program ("BDAT") in March 1987. Additional constituents are added to the BDAT constituent list as more key constituents are identified for specific waste codes or as new analytical methods are developed for hazardous constituents. For example, since the list was published in March 1987, 18 additional constituents (hexavalent chromium, xylenes (all three isomers), benzal chloride, phthalic anhydride, ethylene oxide, acetone, n-butyl alcohol, 2-ethoxyethanol, ethyl acetate, ethyl benzene, ethyl ether, methanol, methyl isobutyl ketone, 2-nitropropane, 1,1,2-trichloro-1,2,2-trifluoroethane, and cyclohexanone) have been added to the list.

Chemicals are listed in Appendix VIII if they are shown in scientific studies to have toxic, carcinogenic, mutagenic, or teratogenic effects on humans or other life-forms, and they include such substances as those identified by the Agency's Carcinogen Assessment Group as being carcinogenic. A waste can be listed as a toxic waste on the basis that it contains a constituent in Appendix VIII.

Although Appendix VII, Appendix VIII, and the F003 and F005 ignitables provide a comprehensive list of RCRA-regulated hazardous constituents, not all of the constituents can be analyzed in a complex

waste matrix. Therefore, constituents that could not be readily analyzed in an unknown waste matrix were not included on the initial BDAT constituent list. As mentioned above, however, the BDAT constituent list is a continuously growing list that does not preclude the addition of new constituents when analytical methods are developed.

There are five major reasons that constituents were not included on the BDAT constituent list:

1. Constituents are unstable. Based on their chemical structure, some constituents will either decompose in water or will ionize. For example, maleic anhydride will form maleic acid when it comes in contact with water, and copper cyanide will ionize to form copper and cyanide ions. However, EPA may choose to regulate the decomposition or ionization products.
2. EPA-approved or verified analytical methods are not available. Many constituents, such as 1,3,5-trinitrobenzene, are not measured adequately or even detected using any of EPA's analytical methods published in SW-846 Third Edition.
3. The constituent is a member of a chemical group designated in Appendix VIII as not otherwise specified (N.O.S.). Constituents listed as N.O.S., such as chlorinated phenols, are a generic group of some types of chemicals for which a single analytical procedure is not available. The individual members of each such group need to be listed to determine whether the constituents can be analyzed. For each N.O.S. group, all those constituents that can be readily analyzed are included in the BDAT constituent list.
4. Available analytical procedures are not appropriate for a complex waste matrix. Some compounds, such as auramine, can be analyzed as a pure constituent. However, in the presence of other constituents, the recommended analytical method does not positively identify the constituent. The use of high performance liquid chromatography (HPLC) presupposes a high expectation of finding the specific constituents of interest. In using this procedure to screen samples, protocols would have to be developed on a case-specific basis to verify the identity of constituents present in the samples. Therefore, HPLC is usually not an appropriate analytical procedure for complex samples containing unknown constituents.

5. Standards for analytical instrument calibration are not commercially available. For several constituents, such as benz(c)acridine, commercially available standards of a "reasonably" pure grade are not available. The unavailability of a standard was determined by a review of catalogs from specialty chemical manufacturers.

Two constituents (fluoride and sulfide) are not specifically included in Appendices VII and VIII; however, these compounds are included on the BDAT list as indicator constituents for compounds from Appendices VII and VIII such as hydrogen fluoride and hydrogen sulfide, which ionize in water.

The BDAT constituent list presented in Table 1-1 is divided into the following nine groups:

- Volatile organics;
- Semivolatile organics;
- Metals;
- Other inorganics;
- Organochlorine pesticides;
- Phenoxyacetic acid herbicides;
- Organophosphorous insecticides;
- PCBs; and
- Dioxins and furans.

The constituents were placed in these categories based on their chemical properties. The constituents in each group are expected to behave similarly during treatment and are also analyzed, with the exception of the metals and the other inorganics, by using the same analytical methods.

(2) Constituent selection analysis. The constituents that the Agency selects for regulation in each waste are, in general, those found in the untreated wastes at treatable concentrations. For certain waste

codes, the target list for the untreated waste may have been shortened (relative to analyses performed to test treatment technologies) because of the extreme unlikelihood that the constituent will be present.

In selecting constituents for regulation, the first step is to develop of list of potentially regulated constituents by summarizing all the constituents that are present or are likely to be present in the untreated waste at treatable concentrations. A constituent is considered present in a waste if the constituent (1) is detected in the untreated waste above the detection limit, (2) is detected in any of the treated residuals above the detection limit, or (3) is likely to be present based on the Agency's analyses of the waste-generating process. In case (2), the presence of other constituents in the untreated waste may interfere with the quantification of the constituent of concern, making the detection limit relatively high and resulting in a finding of "not detected" when, in fact, the constituent is present in the waste. Thus, the Agency reserves the right to regulate such constituents.

After developing a list of potential constituents for regulation. EPA reviews this list to determine if any of these constituents can be excluded from regulation because they would be controlled by regulation of other constituents on the list. This indicator analysis is done for two reasons: (1) it reduces the analytical cost burdens on the treater and (2) it facilitates implementation of the compliance and enforcement program. EPA's rationale for selection of regulated constituents for this waste code is presented in Section 6 of this background document.

(3) Calculation of standards. The final step in the calculation of the BDAT treatment standard is the multiplication of the average accuracy-corrected treatment value by a factor referred to by the Agency as the variability factor. This calculation takes into account that even well-designed and well-operated treatment systems will experience some fluctuations in performance. EPA expects that fluctuations will result from inherent mechanical limitations in treatment control systems, collection of treated samples, and analysis of these samples. All of the above fluctuations can be expected to occur at well-designed and well-operated treatment facilities. Therefore, setting treatment standards utilizing a variability factor should be viewed not as a relaxing of section 3004(m) requirements, but rather as a function of the normal variability of the treatment processes. A treatment facility will have to be designed to meet the mean achievable treatment performance level to ensure that the performance levels remain within the limits of the treatment standard.

The Agency calculates a variability factor for each constituent of concern within a waste treatability group using the statistical calculation presented in Appendix A. The equation for calculating the variability factor is the same as that used by EPA for the development of numerous regulations in the Effluent Guidelines Program under the Clean Water Act. The variability factor establishes the instantaneous maximum based on the 99th percentile value.

There is an additional step in the calculation of the treatment standards in those instances where the ANOVA analysis shows that more than one technology achieves a level of performance that represents BDAT. In such instances, the BDAT treatment standard for each constituent of concern is calculated by first averaging the mean performance value for each technology and then multiplying that value by the highest variability factor among the technologies considered. This procedure ensures that all the technologies used as the basis for the BDAT treatment standards will achieve full compliance.

1.2.5 Compliance with Performance Standards

Usually the treatment standards reflect performance achieved by the best demonstrated available technology (BDAT). As such, compliance with these numerical standards requires only that the treatment level be achieved prior to land disposal. It does not require the use of any particular treatment technology. While dilution of the waste as a means to comply with the standards is prohibited, wastes that are generated in such a way as to naturally meet the standards can be land disposed without treatment. With the exception of treatment standards that prohibit land disposal or that specify use of certain treatment methods, all established treatment standards are expressed as concentration levels.

EPA is using both the total constituent concentration and the concentration of the constituent in the TCLP extract of the treated waste as a measure of technology performance.

For all organic constituents, EPA is basing the treatment standards on the total constituent concentration found in the treated waste. EPA is using this measurement because most technologies for treatment of organics destroy or remove organics compounds. Accordingly, the best measure of performance would be the total amount of constituent remaining after treatment. (NOTE: EPA's land disposal restrictions for solvent waste codes F001-F005 (51 FR 40572) use the TCLP extract value as a measure of performance. At the time that EPA promulgated the treatment standards for F001-F005, useful data were not available on total constituent concentrations in treated residuals, and, as a result, the TCLP data were considered to be the best measure of performance.)

For all metal constituents, EPA is using both total constituent concentration and/or the TCLP extract concentration as the basis for treatment standards. The total constituent concentration is being used when the technology basis includes a metal recovery operation. The underlying principle of metal recovery is that it reduces the amount of metal in a waste by separating the metal for recovery; total constituent concentration in the treated residual, therefore, is an important measure of performance for this technology. Additionally, EPA also believes that it is important that any remaining metal in a treated residual waste not be in a state that is easily leachable; accordingly, EPA is also using the TCLP extract concentration as a measure of performance. It is important to note that for wastes for which treatment standards are based

on a metal recovery process, the facility has to comply with both the total and the TCLP extract constituent concentrations prior to land disposing the waste.

In cases where treatment standards for metals are not based on recovery techniques but rather on stabilization, EPA is using only the TCLP value as a measure of performance. The Agency's rationale is that stabilization is not meant to reduce the concentration of metal in a waste but only to chemically minimize the ability of the metal to leach.

1.2.6 Identification of BDAT

BDAT for a waste must be the "best" of the demonstrated available technologies. EPA determines which technology constitutes "best" after screening the available data from each demonstrated technology, adjusting these data for accuracy, and comparing the performance of each demonstrated technology to that of the others. If only one technology is identified as demonstrated, it is considered "best"; if it is available, the technology is BDAT.

(1) Screening of treatment data. The first activity in determining which of the treatment technologies represent treatment by BDAT is to screen the treatment performance data from each of the demonstrated and available technologies according to the following criteria:

1. Design and operating data associated with the treatment data must reflect a well-designed, well-operated system for each treatment data point. (The specific design and operating parameters for each demonstrated technology for the waste code(s) of interest are discussed in Section 3.2 of this document.)

2. Sufficient QA/QC data must be available to determine the true values of the data from the treated waste. This screening criterion involves adjustment of treated data to take into account that the true value may be different from the measured value. This discrepancy generally is caused by other constituents in the waste that can mask results or otherwise interfere with the analysis of the constituent of concern.
3. The measure of performance must be consistent with EPA's approach to evaluating treatment by type of constituents (e.g., total concentration data for organics, and total concentration and TCLP extract concentration for metals from the residual).

In the absence of data needed to perform the screening analysis, EPA will make decisions on a case-by-case basis as to whether to use the data as a basis for the treatment standards. The factors included in this case-by-case analysis will be the actual treatment levels achieved, the availability of the treatment data and their completeness (with respect to the above criteria), and EPA's assessment of whether the untreated waste represents the waste code of concern.

(2) Comparison of treatment data. In cases in which EPA has treatment data from more than one demonstrated available technology following the screening activity, EPA uses the statistical method known as analysis of variance (ANOVA) to determine if one technology performs significantly better than the others. This statistical method (summarized in Appendix A) provides a measure of the differences between two data sets. Specifically, EPA uses the analysis of variance to determine whether BDAT represents a level of performance achieved by only one technology or represents a level of performance achieved by more than one (or all) of the technologies. If EPA finds that one technology performs significantly better (i.e., is "best"), BDAT treatment standards

are the level of performance achieved by that best technology multiplied by the corresponding variability factor for each regulated constituent. If the Agency finds that the levels of performance for one or more technologies are not statistically different, EPA averages the performance values achieved by each technology and then multiplies this value by the largest variability factor associated with any of the technologies.

(3) Quality assurance/quality control. This section presents the principal quality assurance/quality control (QA/QC) procedures employed in screening and adjusting the data to be used in the calculation of treatment standards. Additional QA/QC procedures used in collecting and screening data for the BDAT program are presented in EPA's Generic Quality Assurance Project Plan for Land Disposal Restrictions Program ("BDAT"), EPA/530-SW-87-011.

To calculate the treatment standards for the land disposal restriction rules, it is first necessary to determine the recovery value for each constituent (the amount of constituent recovered after spiking--which is the addition of a known amount of the constituent--minus the initial concentration in the samples, all divided by the spike amount added) for each spiked sample of the treated residual. Once the recovery values are determined, the following procedures are used to select the appropriate percent recovery value to adjust the analytical data:

1. If duplicate spike recovery values are available for the constituent of interest, the data are adjusted by the lowest available percent recovery value (i.e., the value that will yield the most conservative estimate of treatment achieved). However, if a spike recovery value of less than 20 percent is reported for a specific constituent, the data are not used to set treatment standards because the Agency does not have sufficient confidence in the reported value to set a national standard.
2. If data are not available for a specific constituent but are available for an isomer, then the spike recovery data are transferred from the isomer and the data are adjusted using the percent recovery selected according to the procedure described in (1) above.
3. If data are not available for a specific constituent but are available for a similar class of constituents (e.g., volatile organics, acid-extractable semivolatiles), then spike recovery data available for this class of constituents are transferred. All spike recovery values greater than or equal to 20 percent for a spike sample are averaged and the constituent concentration is adjusted by the average recovery value. If spiked recovery data are available for more than one sample, the average is calculated for each sample and the data are adjusted by using the lowest average value.
4. If matrix spike recovery data are not available for a set of data to be used to calculate treatment standards, then matrix spike recovery data are transferred from a waste that the Agency believes is similar (e.g., if the data represent an ash from incineration, then data from other incinerator ashes could be used). While EPA recognizes that transfer of matrix spike recovery data from a similar waste is not an exact analysis, this is considered the best approach for adjusting the data to account for the fact that most analyses do not result in extraction of 100 percent of the constituent. In assessing the recovery data to be transferred, the procedures outlined in (1), (2), and (3) above are followed.

The analytical procedures employed to generate the data used to calculate the treatment standards are listed in Appendix B of this document. In cases where alternatives or equivalent procedures and/or equipment are allowed in EPA's SW-846, Third Edition methods, the

specific procedures and equipment used are documented. In addition, any deviations from the SW-846, Third Edition methods used to analyze the specific waste matrices are documented. It is important to note that the Agency will use the methods and procedures delineated in Appendix B to enforce the treatment standards presented in Section 7 of this document. Accordingly, facilities should use these procedures in assessing the performance of their treatment systems.

1.2.7 BDAT Treatment Standards for "Derived-From" and "Mixed" Wastes

(1) Wastes from treatment trains generating multiple residues. In a number of instances, the proposed BDAT consists of a series of operations, each of which generates a waste residue. For example, the proposed BDAT for a certain waste code is based on solvent extraction, steam stripping, and activated carbon adsorption. Each of these treatment steps generates a waste requiring treatment--a solvent-containing stream from solvent extraction, a stripper overhead, and spent activated carbon. Treatment of these wastes may generate further residues; for instance, spent activated carbon (if not regenerated) could be incinerated, generating an ash and possibly a scrubber water waste. Ultimately, additional wastes are generated that may require land disposal. With respect to these wastes, the Agency wishes to emphasize the following points:

1. All of the residues from treating the original listed wastes are likewise considered to be the listed waste by virtue of the derived-from rule contained in 40 CFR 261.3(c)(2). (This point is discussed more fully in (2) below.) Consequently, all of the wastes generated in the course of treatment would be prohibited from land disposal unless they satisfy the treatment standard or meet one of the exceptions to the prohibition.

2. The Agency's proposed treatment standards generally contain a concentration level for wastewaters and a concentration level for nonwastewaters. The treatment standards apply to all of the wastes generated in treating the original prohibited waste. Thus, all derived-from wastes meeting the Agency definition of wastewater (less than 1 percent total organic carbon (TOC) and less than 1 percent total suspended solids) would have to meet the treatment standard for wastewaters. All residuals not meeting this definition would have to meet the treatment standard for nonwastewaters. EPA wishes to make clear that this approach is not meant to allow partial treatment in order to comply with the applicable standard.
3. The Agency has not performed tests, in all cases, on every waste that can result from every part of the treatment train. However, the Agency's treatment standards are based on treatment of the most concentrated form of the waste. Consequently, the Agency believes that the less concentrated wastes generated in the course of treatment will also be able to be treated to meet this value.

(2) Mixtures and other derived-from residues. There is a further question as to the applicability of the BDAT treatment standards to residues generated not from treating the waste (as discussed above), but from other types of management. Examples are contaminated soil or leachate that is derived from managing the waste. In these cases, the mixture is still deemed to be the listed waste, either because of the derived-from rule (40 CFR 261.3(c)(2)(i)) or the mixture rule (40 CFR 261.3(a)(2)(iii) and (iv)) or because the listed waste is contained in the matrix (see, for example, 40 CFR 261.33(d)). The prohibition for the particular listed waste consequently applies to this type of waste.

The Agency believes that the majority of these types of residues can meet the treatment standards for the underlying listed wastes (with the possible exception of contaminated soil and debris for which the Agency is currently investigating whether it is appropriate to establish a

separate treatability subcategorization). For the most part, these residues will be less concentrated than the original listed waste. The Agency's treatment standards also make a generous allowance for process variability by assuming that all treatability values used to establish the standard are lognormally distributed. The waste also might be amenable to a relatively nonvariable form of treatment technology such as incineration. Finally, and perhaps most important, the rules contain a treatability variance that allows a petitioner to demonstrate that its waste cannot be treated to the level specified in the rule (40 CFR Part 268.44(a)). This provision provides a safety valve that allows persons with unusual waste matrices to demonstrate the appropriateness of a different standard. The Agency, to date, has not received any petitions under this provision (for example, for residues contaminated with a prohibited solvent waste), indicating, in the Agency's view, that the existing standards are generally achievable.

(3) Residues from managing listed wastes or that contain listed wastes. The Agency has been asked if and when residues from managing hazardous wastes, such as leachate and contaminated ground water, become subject to the land disposal prohibitions. Although the Agency believes this question to be settled by existing rules and interpretative statements, to avoid any possible confusion the Agency will address the question again.

Residues from managing First Third wastes, listed California List wastes, and spent solvent and dioxin wastes are all considered to be subject to the prohibitions for the listed hazardous waste as originally generated. Residues from managing California List wastes likewise are subject to the California List prohibitions when the residues themselves exhibit a characteristic of hazardous waste. This determination stems directly from the derived-from rule in 40 CFR 261.3(c)(2) or, in some cases, from the fact that the waste is mixed with or otherwise contains the listed waste. The underlying principle stated in all of these provisions is that listed wastes remain listed until delisted.

The Agency's historic practice in processing delisting petitions that address mixing residuals has been to consider them to be the listed waste and to require that delisting petitioners address all constituents for which the derived-from waste (or other mixed waste) was listed. The language in 40 CFR 260.22(b) states that mixtures or derived-from residues can be delisted provided a delisting petitioner makes a demonstration identical to that which a delisting petitioner would make for the original listed waste. Consequently, these residues are treated as the original listed waste for delisting purposes. The statute likewise takes this position, indicating that soil and debris that are contaminated with listed spent solvents or dioxin wastes are subject to the prohibition for these wastes even though these wastes are not the originally generated waste, but rather are a residual from management (RCRA section 3004(e)(3)). It is EPA's view that all such residues are

covered by the existing prohibitions and treatment standards for the listed hazardous waste that these residues contain or from which they are derived.

1.2.8 Transfer of Treatment Standards

EPA is proposing some treatment standards that are not based on testing of the treatment technology on the specific waste subject to the treatment standard. The Agency has determined that the constituents present in the untested waste can be treated to the same performance levels as those observed in other wastes for which EPA has previously developed treatment data. EPA believes that transferring treatment performance data for use in establishing treatment standards for untested wastes is technically valid in cases where the untested wastes are generated from similar industries or processing steps, or have similar waste characteristics affecting performance and treatment selection. Transfer of treatment standards to similar wastes or wastes from similar processing steps requires little formal analysis. However, in a case where only the industry is similar, EPA more closely examines the waste characteristics prior to deciding whether the untested waste constituents can be treated to levels associated with tested wastes.

EPA undertakes a two-step analysis when determining whether constituents in the untested wastes can be treated to the same level of performance as in the tested waste. First, EPA reviews the available waste characterization data to identify those parameters that are

expected to affect treatment selection. EPA has identified some of the most important constituents and other parameters needed to select the treatment technology appropriate for the given waste(s) in Section 3.

Second, when analysis suggests that an untested waste can be treated with the same technology as a waste for which treatment performance data are already available, EPA analyzes a more detailed list of characteristics that the Agency believes will affect the performance of the technology. By examining and comparing these characteristics, the Agency determines whether the untested wastes will achieve the same level of treatment as the tested waste. Where the Agency determines that the untested waste can be treated as well or better than the tested waste, the treatment standards can be transferred.

1.3 Variance from the BDAT Treatment Standard

The Agency recognizes that there may exist unique wastes that cannot be treated to the level specified as the treatment standard. In such a case, a generator or owner/operator may submit a petition to the Administrator requesting a variance from the treatment standard. A particular waste may be significantly different from the wastes on which the treatment standards are based because the subject waste contains a more complex matrix that makes it more difficult to treat. For example, complex mixtures may be formed when a restricted waste is mixed with other waste streams by spills or other forms of inadvertent mixing. As a result, the treatability of the restricted waste may be altered such that it cannot meet the applicable treatment standard.

Variance petitions must demonstrate that the treatment standard established for a given waste cannot be met. This demonstration can be made by showing that attempts to treat the waste by available technologies were not successful or by performing appropriate analyses of the waste, including waste characteristics affecting performance, which demonstrate that the waste cannot be treated to the specified levels. Variances will not be granted based solely on a showing that adequate BDAT treatment capacity is unavailable. (Such demonstrations can be made according to the provisions in Part 268.5 of RCRA for case-by-case extensions of the effective date.) The Agency will consider granting generic petitions provided that representative data are submitted to support a variance for each facility covered by the petition.

Petitioners should submit at least one copy to:

The Administrator
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, DC 20460

An additional copy marked "Treatability Variance" should be submitted to:

Chief, Waste Treatment Branch
Office of Solid Waste (WH-565)
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, DC 20460

Petitions containing confidential information should be sent with only the inner envelope marked "Treatability Variance" and "Confidential Business Information" and with the contents marked in accordance with the

requirements of 40 CFR Part 2 (41 FR 36902, September 1, 1976, amended by 43 FR 4000).

The petition should contain the following information:

1. The petitioner's name and address.
2. A statement of the petitioner's interest in the proposed action.
3. The name, address, and EPA identification number of the facility generating the waste, and the name and telephone number of the plant contact.
4. The process(es) and feed materials generating the waste and an assessment of whether such process(es) or feed materials may produce a waste that is not covered by the demonstration.
5. A description of the waste sufficient for comparison with the waste considered by the Agency in developing BDAT, and an estimate of the average and maximum monthly and annual quantities of waste covered by the demonstration. (Note: The petitioner should consult the appropriate BDAT background document for determining the characteristics of the wastes considered in developing treatment standards.)
6. If the waste has been treated, a description of the system used for treating the waste, including the process design and operating conditions. The petition should include the reasons the treatment standards are not achievable and/or why the petitioner believes the standards are based on inappropriate technology for treating the waste. (Note: The petitioner should refer to the BDAT background document as guidance for determining the design and operating parameters that the Agency used in developing treatment standards.)
7. A description of the alternative treatment systems examined by the petitioner (if any); a description of the treatment system deemed appropriate by the petitioner for the waste in question; and, as appropriate, the concentrations in the treatment residual or extract of the treatment residual (i.e., using the TCLP, where appropriate, for stabilized metals) that can be achieved by applying such treatment to the waste.
8. A description of those parameters affecting treatment selection and waste characteristics that affect performance, including results of all analyses. (See Section 3 for a discussion of

waste characteristics affecting performance that the Agency has identified for the technology representing BDAT.)

9. The dates of the sampling and testing.
10. A description of the methodologies and equipment used to obtain representative samples.
11. A description of the sample handling and preparation techniques, including techniques used for extraction, containerization, and preservation of the samples.
12. A description of analytical procedures used, including QA/QC methods.

After receiving a petition for a variance, the Administrator may request any additional information or waste samples that may be required to evaluate and process the petition. Additionally, all petitioners must certify that the information provided to the Agency is accurate under 40 CFR 268.4(b).

In determining whether a variance will be granted, the Agency will first look at the design and operation of the treatment system being used. If EPA determines that the technology and operation are consistent with BDAT, the Agency will evaluate the waste to determine if the waste matrix and/or physical parameters are such that the BDAT treatment standards reflect treatment of this waste. Essentially, this latter analysis will concern the parameters affecting treatment selection and waste characteristics affecting performance parameters.

In cases where BDAT is based on more than one technology, the petitioner will need to demonstrate that the treatment standard cannot be met using any of the technologies, or that none of the technologies are

appropriate for treatment of the waste. After the Agency has made a determination on the petition, the Agency's findings will be published in the Federal Register, followed by a 30-day period for public comment. After review of the public comments, EPA will publish its final determination in the Federal Register as an amendment to the treatment standards in 40 CFR Part 268, Subpart D.

2. INDUSTRIES AFFECTED AND WASTE CHARACTERIZATION

According to 40 CFR 261.32, the following chlorine industry wastes are subject to the land disposal restriction provisions of HSWA:

- K071: Brine purification muds from the mercury cell process in chlorine production, where separately prepurified brine is not used.
- K073: Chlorinated hydrocarbon waste from the purification step of the diaphragm cell process using graphite anodes in chlorine production.
- K106: Wastewater treatment sludge from the mercury cell process in chlorine production.

K071 waste is the subject of this background document.

This section discusses the industry affected by the land disposal restrictions for K071 waste, describes the process generating the waste, and presents a summary of available waste characterization data for the waste.

2.1 Industries Affected and Process Description

Chlorine is produced primarily from the electrolytic decomposition of either sodium chloride or potassium chloride, from which the coproducts are sodium hydroxide (caustic soda) or potassium hydroxide. All of the caustic soda and potassium hydroxide and over 90 percent of the chlorine produced in the U.S. are made by the electrolytic decomposition of sodium chloride or potassium chloride. Chlorine is also produced from the nonelectrolytic oxidation of hydrochloric acid (HCl), from the production of sodium metal, and from the electrolytic production of magnesium metal from molten magnesium chloride.

Three types of electrolytic cells are in commercial use for the production of alkalies and chlorine: the mercury cell, the diaphragm cell, and the membrane cell. The listed waste K071 is generated in chlorine production by the mercury cell process. The Agency estimates that there are 20 facilities producing chlorine by the mercury cell process and that 14 of these facilities do not use prepurified brine and therefore may generate K071 waste. The number and locations of these facilities are provided in Table 2-1, listed by State, and in Table 2-2, listed by EPA Region. Chlorine producers fall under Standard Industrial Classification (SIC) Code 2812.

In chlorine production by the mercury cell process, a saturated salt brine solution is prepared in a brine saturator tank by dissolving sodium chloride, usually in the form of rock salt, into depleted brine solution recycled from the mercury cells. The saturated solution then undergoes brine purification, which removes impurities that were present in the raw salt. In brine purification, hydroxides, carbonates, and/or sulfates are added to remove calcium, magnesium, and iron impurities by precipitation. After precipitation, the saturated solution is sent through clarification and filtration, where the precipitated solids are removed. The purified saturated brine is then fed to the mercury cells, where electrolytic decomposition into sodium and chlorine occurs.

The K071 waste is generated from two sources in the brine purification process: (1) the insoluble materials from the salt that settle to the bottom of the brine saturator tank (these muds are commonly

Table 2-1 Number of Producers of Chlorine Using the
Mercury Cell Process Listed by State

State	Number of producers ^a
Alabama (IV)	3
Delaware (III)	1
Georgia (IV)	1 (1)
Kentucky (IV)	1
Louisiana (VI)	1 (1)
Maine (I)	1
New York (II)	1 (1)
North Carolina (IV)	1
Ohio (V)	1
Tennessee (IV)	1
Texas (VI)	0 (1)
Washington (X)	1
West Virginia (III)	0 (2)
Wisconsin (V)	<u>1</u>
Total	14(6)

^aNumbers in parentheses are numbers of additional facilities that use prepurified salt in the process and therefore do not currently generate K071 waste.

Reference: SRI 1987.

Table 2-2 Number of Producers of Chlorine Using
the Mercury Cell Process Listed by EPA Region

EPA Region	Number of producers ^a
I	1
II	1 (1)
III	1 (2)
IV	7 (1)
V	2
VI	1 (2)
X	<u>1</u>
Total	14 (6)

^aNumbers in parentheses are numbers of additional facilities that use prepurified salt in the process and therefore do not currently generate K071 waste.

Reference: SRI 1987.

referred to as saturator insolubles) and (2) the solids removed by clarification and filtration.

2.2 Waste Characterization

This section includes all waste characterization data available to the Agency for K071 waste. The major constituents and their approximate concentrations are presented in Table 2-3. The ranges of concentrations for the BDAT list constituents detected in the waste are presented in Table 2-4.

Table 2-3 Major Constituent Analysis of Untreated K071 Waste

Major constituent	Concentration (wt. %)					
	(1)	(1)	(2)	(2)	(2)	(3) ^a
Calcium	-	-	17	-	-	-
Calcium carbonate	7.4	8.0	-	19.2-24.8	20	30-40
Calcium sulfate	9.5	1.8	-	-	-	50-60
Calcium chloride	-	2.0	-	-	-	-
Chloride	-	-	9.4	-	-	-
Graphite	-	-	-	1.1-5.5	-	-
Iron and aluminum hydroxides	<0.1	-	-	1.1-3.3	0.3	-
Magnesium carbonate	0.3	1.2	-	11-16.5	-	-
Magnesium hydroxide	<0.1	-	-	-	3.0	-
Sodium chloride	19.0	67.1	-	5.5-11	-	5-15
Sodium hydroxide	0.1	-	-	-	-	-
Sodium sulfate	0.2	-	-	-	-	-
Sulfate	-	-	3.2	-	-	-
Other solids	-	17.8	-	-	30	-
Water	63.4	2.1	41	45	46.7	-
BOAT metals	<0.1	-	<0.1	-	-	-

^aReported on a dry basis.

References:

- (1) USEPA 1988a. Section 1.2.
- (2) USEPA 1986a.
- (3) Bennett 1986.

Table 2-4 BDAT List Constituent Concentrations in Untreated K071 Waste

Constituents	Concentration					
	data source					
	(1)	(1)	(2)	(3)	(4)	(4)
<u>Volatile Organic Compounds:</u>						
Bromodichloromethane	ug/l	62	<25	-	-	-
Bromoform (tribromomethane)	ug/l	550	<25	-	-	-
Chlorodibromomethane	ug/l	170	<25	-	-	-
Chloroform	ug/l	200	<25	-	-	-
<u>Metals:</u>						
Antimony	mg/l	ND	ND	10.0	-	-
Arsenic	mg/l	ND	ND	-	-	-
Barium	mg/l	0.57-1.1	1.4	-	-	-
Beryllium	mg/l	ND	ND	-	-	-
Cadmium	mg/l	ND	ND	3.8	-	-
Chromium	mg/l	ND	ND	5.9	-	-
Copper	mg/l	ND	1.19-<4.0	184.7	-	-
Lead	mg/l	ND	ND	47.8	-	-
Mercury	mg/l	17.0-22.1	1.12	73.8	4.4-172.8	14
Nickel	mg/l	3.15-<6.5	7.9	90.3	-	-
Selenium	mg/l	ND	ND	-	-	-
Silver	mg/l	ND	ND	-	-	-
Thallium	mg/l	7.74-<43	ND	-	-	-
Vanadium	mg/l	ND	ND	-	-	-
Zinc	mg/l	2.29-3.18	2.5	128.0	-	-

- = Not analyzed.

ND = Not detected.

References:

- (1) USEPA 1988a. Tables 5-2 through 5-8, 5-12, and 5-14.
- (2) USEPA 1986a.
- (3) Olin Chemicals 1988 (LDR7-00055).
- (4) Bennett 1986.

3. APPLICABLE/DEMONSTRATED TREATMENT TECHNOLOGIES

This section identifies the applicable and demonstrated treatment technologies for treatment of K071 waste. Detailed discussions are provided for those technologies that are demonstrated. Information on the applicable and demonstrated treatment technologies comes from literature sources, engineering site visits, and industry submittals.

3.1 Applicable Treatment Technologies

The technologies that are considered to be applicable for treatment of K071 waste are those that treat toxic metals (especially mercury, the constituent for which the waste was listed) by reducing the metal concentration and/or leachability in the waste. For K071 nonwastewater, the Agency has identified the following treatment technologies, either alone or in combination, as being applicable: acid leaching, chemical oxidation, sludge dewatering combined with either acid or water washing, stabilization, and retorting. For K071 wastewater produced during treatment or handling of K071 waste (e.g., wastewaters generated from sludge dewatering), the Agency has identified chemical precipitation and filtration as being applicable.

3.2 Demonstrated Treatment Technologies

The demonstrated technologies for K071 nonwastewater are acid leaching, chemical oxidation, and sludge dewatering combined with either acid or water washing. The Agency has identified two facilities that use a treatment system consisting of acid leaching followed by chemical oxidation and then sludge dewatering/acid washing; one facility that uses acid leaching (percolation) alone; and three facilities that use sludge

dewatering/water washing.

Stabilization is not currently being used to treat K071 waste or wastes that are similar with regard to parameters that affect the applicability of the technology. Retorting, the only remaining applicable technology for the nonwastewater, is not currently being used to treat K071 waste or similar wastes. Accordingly, EPA does not believe that either of these technologies is demonstrated for K071.

For K071 wastewater, chemical precipitation followed by filtration is demonstrated; several facilities treat K071 wastewater using this technology.

Sludge dewatering/water washing, used alone to treat K071 at three facilities identified by EPA, removes mercury present in the waste by washing and separating liquids from the solid portion. The solid portion is the treated K071 nonwastewater. The liquids removed are K071 wastewater.

The acid leaching, chemical oxidation, and sludge dewatering/acid washing treatment system, used for treatment of K071 nonwastewaters at two of the facilities identified by EPA, removes mercury from the waste as soluble mercuric chloride, generating a nonwastewater residual with reduced concentrations of hazardous metal constituents and a wastewater containing the acid-leached metals. This wastewater requires further treatment. A schematic diagram of this treatment system is provided in Figure 3-1. In the acidification step, sulfuric acid is added to the waste to reduce the pH. In a simultaneous reaction, the calcium in the waste is precipitated as calcium sulfate (CaSO_4). In the next process

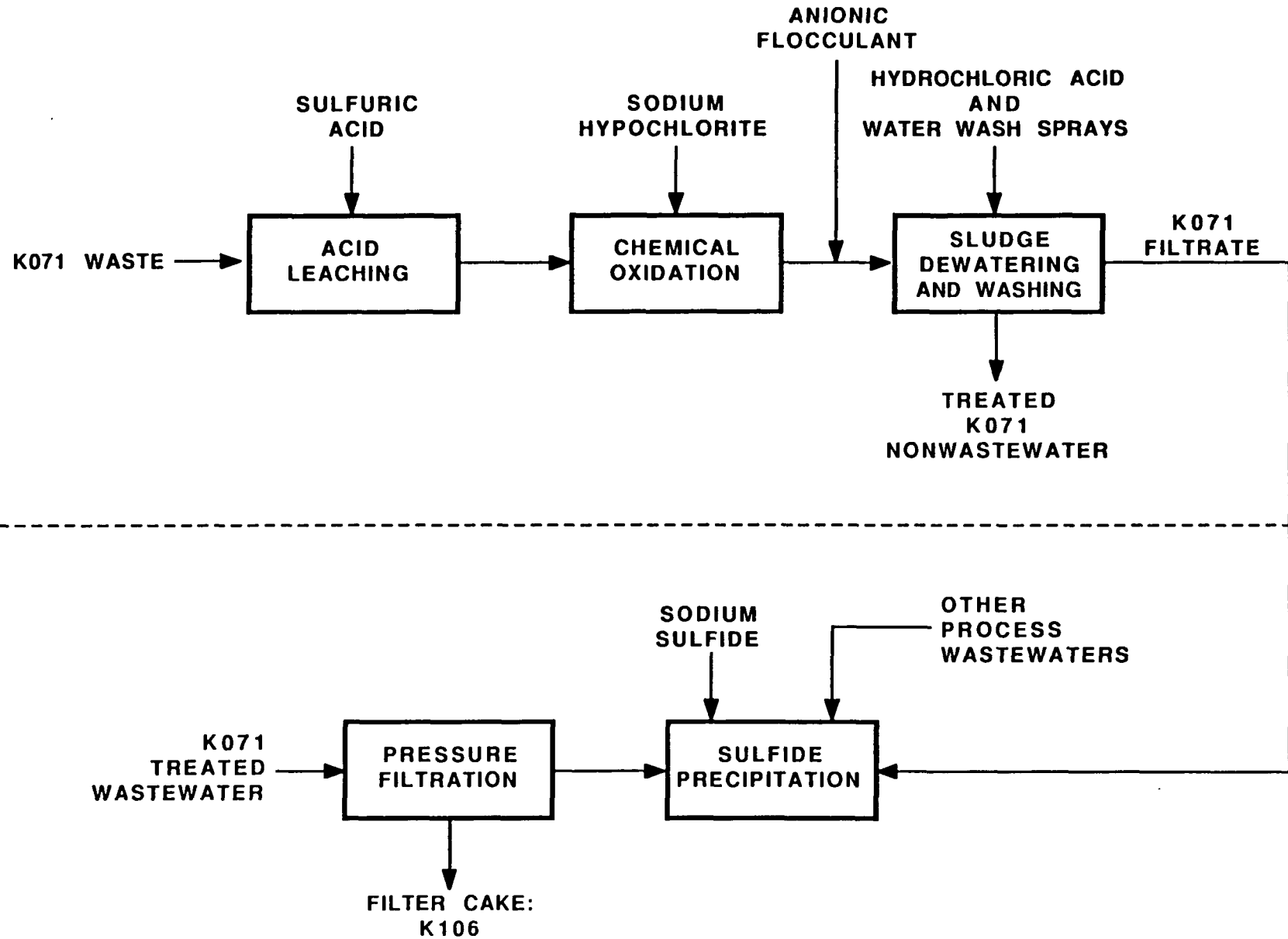


FIGURE 3-1 SCHEMATIC OF K071 WASTE TREATMENT PROCESS

step, chemical oxidation, any elemental mercury present in the waste is solubilized by reaction with sodium hypochlorite (NaOCl) to form mercuric chloride (HgCl_2). After chemical oxidation, the waste is fed to a filter equipped with hydrochloric acid and water wash sprays, where the solids are washed and dewatered.

The K071 wastewater, which contains dissolved mercury as HgCl_2 , is treated by sulfide precipitation and filtration. Mercury is removed as the sulfide, HgS , in a wastewater treatment sludge listed as K106.

Overall, treatment of K071 waste results in the formation of a treated solid residual from the sludge dewatering step and both a treated wastewater and a solid residual from the sulfide precipitation/filtration step. The treated residual from the sludge dewatering step is analyzed to determine the performance of treatment for nonwastewater. The treated wastewater from sulfide precipitation and filtration is analyzed to determine the performance treatment for wastewater.

The following demonstrated technologies or treatment steps are discussed in detail below: acid leaching, sludge filtration (sludge dewatering), and chemical precipitation.

3.2.1 Acid Leaching

Acid leaching is a process that removes a soluble constituent or constituents from a relatively insoluble solid phase by contacting the solids with an acidic solution. The spent acid will concentrate the leached constituent or constituents, and will then be subject to further treatment. A treatment system for acid leaching usually consists of some

type of solid/liquid contacting system followed by equipment for solid/liquid separation.

(1) Applicability and use of acid leaching. Acid leaching can be applied to treatment of wastes in solid or slurry form when the hazardous constituents of the waste are soluble in a strong acid solution or can be converted by reaction with a strong acid to a soluble form. It frequently is used to remove metals from sludges.

(2) Underlying principles of operation. The underlying principle of operation for acid leaching is that by lowering the pH of the waste, metals can be concentrated in a solution passing through the waste because of the higher solubility associated with acidic pH values.

In order to assure effective removal of metals, strong acids, such as sulfuric (H_2SO_4), hydrochloric (HCl), nitric (HNO_3), and hydrofluoric (HF), frequently are used. Separation of the liquids from the treated solids can be accomplished either by designing solid/liquid contacting equipment used in the leaching step to retain solids and release liquids, or by additional separation steps such as filtration.

(3) Description of the acid leaching process. Acid leaching processes can be categorized into two major types: (a) treatment by percolation of the acid through the solids, and (b) treatment by dispersion of the solids in the acid and then subsequent separation of the solids from the liquid.

(a) Percolation processes. Percolation is carried out in batch tanks and in several designs of continuous percolation equipment. Batch percolators are large tanks. The solids are placed in the tank and the acid is fed onto the solids. The acid percolates through the solids and drains out through screens or porous media in the tank bottom. The acid may flow countercurrently through a series of tanks, with fresh acid being added to the tank containing the most nearly exhausted solids. Following treatment, the solids are removed.

Continuous percolation is carried out in moving-bed equipment, where the acid normally flows countercurrently to the solids (see Figure 3-2). The acid drains from each solids bed to the solids bed beneath.

(b) Dispersed-solids processes. Leaching by dispersion of fine solids into the acid is performed in batch tanks or in a variety of continuous devices. In the batch and continuous systems, the untreated waste and the acid are mixed in the reaction tank. Following mixing, the treated solids are separated from the acid; separation can be accomplished either by settling or filtration, depending on the type and concentration of solids involved. In both systems, sufficient acid must be supplied to keep the pH at a level necessary to effectively leach the metals from the waste.

(4) Waste characteristics affecting performance. In determining whether an untested waste can be treated to the same level of performance as a previously tested waste, the waste characteristics EPA will examine for the acid leaching process are: (a) the solid particle size, (b) the neutralizing capacity (or alkalinity) of the solids being treated, and

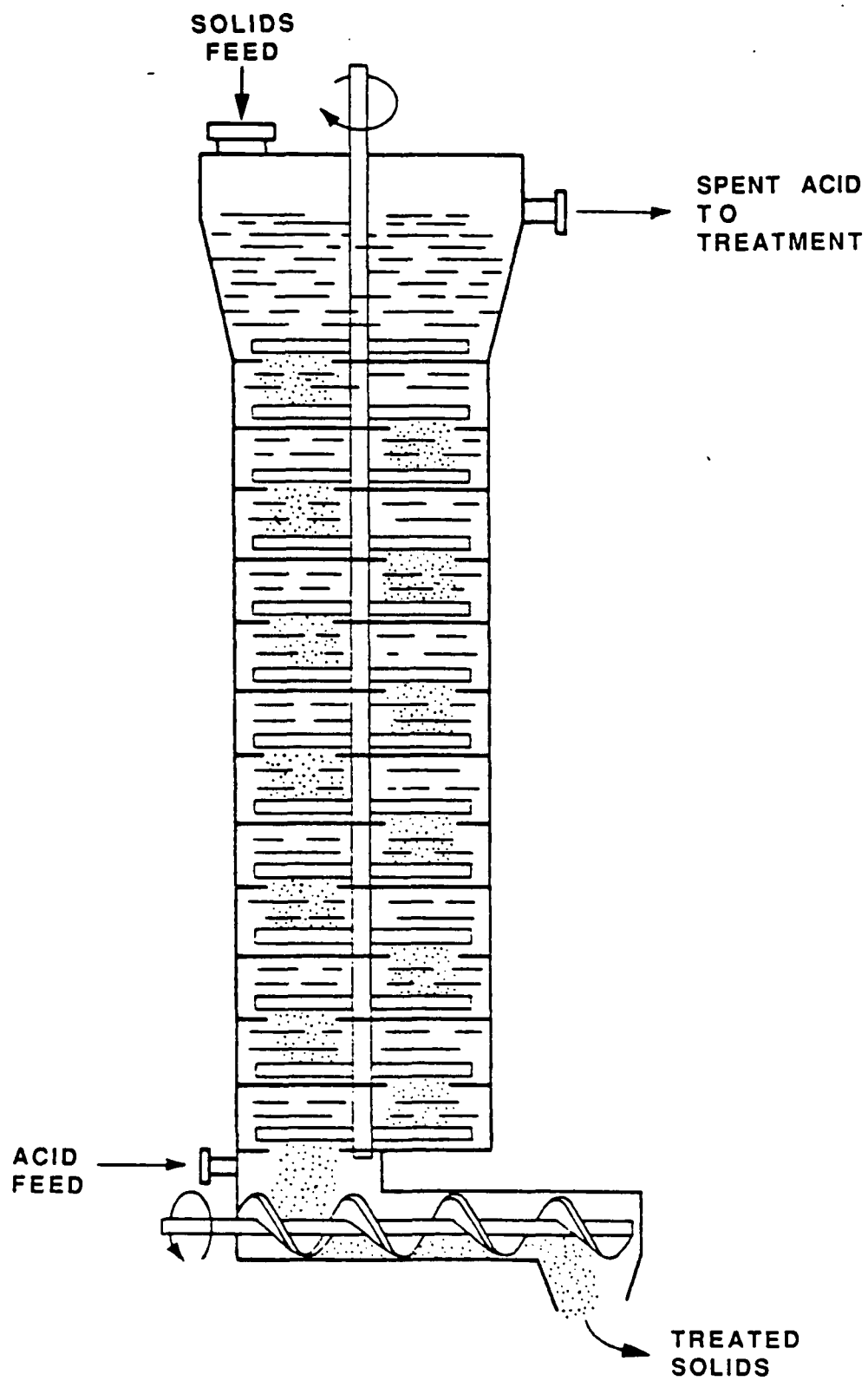


FIGURE 3-2
CONTINUOUS EXTRACTOR

(c) the type and chemical form of the hazardous metal constituent(s) in the waste.

(a) Particle size. The reaction rate of the acid with the hazardous constituent(s) of the waste, and the rate of transport of acid to and from the site of the hazardous constituent, are both affected by the size of the solid particles. The smaller the particles, the more rapidly they will leach because of the increased surface area that is exposed to acid.

(b) Neutralizing capacity. The neutralizing capacity, or alkalinity, of the solid affects the amount of acid that must be added to the waste in order to achieve and/or maintain the desired reactor pH. In addition to dissolving the waste contaminants, the acid also will dissolve some of the alkali bulk solids. Therefore, highly alkaline wastes require more acid or a stronger acid in order to maintain the pH during treatment.

(c) Type and chemical form of hazardous metal constituent(s). The type of metal(s) present will affect the degree to which acid leaching will be effective. Different metals will have different solubilities and thus impact the removal that can be achieved.

The chemical form of each of the hazardous metal constituents is also important in determining the reactivity and/or solubility of the constituent. For example, mercury may exist in waste as mercuric oxide (HgO) or metallic mercury (Hg). Reaction with a strong acid and a source of chloride will transform the less soluble HgO into the more soluble mercuric chloride form ($\text{HgO} + 2\text{HCl} \rightarrow \text{HgCl}_2 + \text{H}_2\text{O}$). This will

allow removal of mercury present as HgO . Conversely, metallic mercury (Hg) will not react with acid to form HgCl_2 and will not leach.

(5) Design and operating parameters. The design and operating parameters of an acid leaching system that affect performance are:
(a) contact time between the solid and the acid, (b) choice of acid used, (c) pH, and (d) type of contactor used.

(a) Contact time. In continuous percolation systems, contact time is usually specified by the design volume of the equipment or the speed of the moving bed. For a given contact time, the performance of either a continuous or a batch percolation system can be increased by using a countercurrent flow of acid. In all acid leaching systems, the extent of reaction and dissolution of the contaminant are directly related to the contact time.

(b) Choice and concentration of acid used. If the hazardous constituents to be removed in the acid leaching system are already present in the waste in a soluble form, or are solubilized by pH reduction, then any acid that will reduce the pH to the desired value may be used. However, if chemical reaction is necessary to form the soluble species, then the appropriate acid must be used at the proper concentration. If selection of the acid will have an effect on the nonhazardous constituents of the waste (i.e., the acid may precipitate an alkali metal salt such as calcium sulfate), then an acid that produces a waste that can be more effectively separated by a solid/liquid separation device (such as a filter or a centrifuge) should be used.

(c) pH. For dispersed-solids systems, the feed of acid to the treatment reactor should be based on pH monitoring and control, since the reaction rate is likely to be highly pH dependent. Because reaction rate in acid leaching depends on pH, a pH should be selected, based on the contact time and amount of the hazardous constituent(s) in the waste as determined by laboratory testing, that provides for complete reaction in the contact time provided. Also, the effect that the pH may have on the composition or characteristics of the nonhazardous constituents of the waste should be considered. For example, if maintenance of a certain pH value leads to formation of solids that will allow the most efficient solid/liquid separation after leaching is completed, then pH should be maintained at this value.

For percolation systems, pH monitoring of the acid percolating through the tank bottom should ensure that enough acid is being added. If the pH is not low enough, additional acid may be added.

(d) Type of contactor used. The performance of an acid leaching system depends on the type of contacting system used. Additionally, acid leaching processes are affected by the number of contacting stages and the type of flow pattern of the acid (countercurrent or cocurrent).

3.2.2 Sludge Filtration

(1) Applicability and use of sludge filtration. Sludge filtration, also known as sludge dewatering or cake-formation filtration, is a technology used on wastes that contain high concentrations of suspended solids, generally higher than 1 percent. The remainder of the waste is

essentially water. Sludge filtration is applied to sludges, typically those that have settled to the bottom of clarifiers, for dewatering. After filtration, these sludges can be dewatered to 20 to 50 percent solids.

(2) Underlying principles of operation. The basic principle of filtration is the separation of particles from a mixture of fluids and particles by a medium that permits the flow of the fluid but retains the particles. As would be expected, larger particles are easier to separate from the fluid than smaller particles. Extremely small particles, in the colloidal range, may not be filtered effectively and may appear in the treated waste. To mitigate this problem, the wastewater should be treated prior to filtration to modify the particle size distribution in favor of the larger particles, by the use of appropriate precipitants, coagulants, flocculants, and filter aids. The selection of the appropriate precipitant or coagulant is important because it affects the particles formed. For example, lime neutralization usually produces larger, less gelatinous particles than does caustic soda precipitation. For larger particles that become too small to filter effectively because of poor resistance to shearing, shear resistance can be improved by the use of coagulants and flocculants. Also, if pumps are used to feed the filter, shear can be minimized by designing for a lower pump speed or by use of a low shear type of pump.

(3) Description of the sludge filtration process. For sludge filtration, settled sludge is either pumped through a cloth-type filter media (such as in a plate and frame filter that allows solid "cake" to

build up on the media) or the sludge is drawn by vacuum through the cloth media (such as on a drum or vacuum filter, which also allows the solids to build). In both cases, the solids themselves act as a filter for subsequent solids removal. For a plate and frame type filter, removal of the solids is accomplished by taking the unit off line, opening the filter, and scraping the solids off. For the vacuum type filter, cake is removed continuously. For a specific sludge, the plate and frame type filter will usually produce a drier cake than a vacuum filter. Other types of sludge filters, such as belt filters, are also used for effective sludge dewatering.

(4) Waste characteristics affecting performance. The following characteristics of the waste will affect performance of a sludge filtration unit: (a) size of particles and (b) type of particles.

(a) Size of particles. The smaller the particle size, the more the particles tend to go through the filter media. This is especially true for a vacuum filter. For a pressure filter (like a plate and frame), smaller particles may require higher pressures for equivalent throughput, since the smaller pore spaces between particles create resistance to flow.

(b) Type of particles. Some solids formed during metal precipitation are gelatinous in nature and cannot be dewatered well by cake-formation filtration. In fact, for vacuum filtration a cake may not form at all. In most cases, solids can be made less gelatinous by use of the appropriate coagulants and coagulant dosage prior to clarification, or after clarification but prior to filtration. In addition, the use of

lime instead of caustic soda in metal precipitation will reduce the formation of gelatinous solids. Also, the addition of filter aids, such as lime or diatomaceous earth, to a gelatinous sludge will help significantly. Finally, precoating the filter with diatomaceous earth prior to sludge filtration will assist in dewatering gelatinous sludges.

(5) Design and operating parameters. For sludge filtration, the following design and operating variables affect performance: (a) type of filter selected, (b) size of filter selected, (c) feed pressure, and (d) use of coagulants or filter aids.

(a) Type of filter. Typically, pressure type filters (such as a plate and frame) will yield a drier cake than a vacuum type filter and will also be more tolerant of variations in influent sludge characteristics. Pressure type filters, however, are batch operations, so that when cake is built up to the maximum depth physically possible (constrained by filter geometry), or to the maximum design pressure, the filter is turned off while the cake is removed. A vacuum filter is a continuous device (i.e., cake discharges continuously), but will usually be much larger than a pressure filter with the same capacity. A hybrid device is a belt filter, which mechanically squeezes sludge between two continuous fabric belts.

(b) Size of filter. As with in-depth filters, the larger the filter, the greater its hydraulic capacity and the longer the filter runs between cake discharge.

(c) Feed pressure. This parameter impacts both the design pore size of the filter and the design flow rate. In treating waste, it is

important that the design feed pressure not be exceeded; otherwise, particles may be forced through the filter medium, resulting in ineffective treatment.

(d) Use of coagulants. Coagulants and filter aids may be mixed with filter feed prior to filtration. Their effect is particularly significant for vacuum filtration since in a vacuum filter their use may make the difference between no cake and a relatively dry cake. In a pressure filter, coagulants and filter aids will also significantly improve hydraulic capacity and cake dryness. Filter aids, such as diatomaceous earth, can be precoated on filters (vacuum or pressure) for sludges that are particularly difficult to filter. The precoat layer acts somewhat like an in-depth filter in that sludge solids are trapped in the precoat pore spaces. Use of precoats and most coagulants or filter aids significantly increases the amount of sludge solids to be disposed of. However, polyelectrolyte coagulant usage usually does not increase sludge volume significantly because the dosage is low.

3.2.3 Chemical Precipitation

(1) Applicability and use of chemical precipitation. Chemical precipitation is used when dissolved metals are to be removed from solution. This technology can be applied to a wide range of wastewaters containing dissolved BDAT list metals and other metals as well. This treatment process has been practiced widely by industrial facilities since the 1940s.

(2) Underlying principles of operation. The underlying principle of chemical precipitation is that metals in wastewater are removed by the

addition of a treatment chemical that converts the dissolved metal to a metal precipitate. This precipitate is less soluble than the original metal compound and therefore settles out of solution, leaving a lower concentration of the metal present in the solution. The principal chemicals used to convert soluble metal compounds to the less soluble forms include lime (Ca(OH)_2), caustic (NaOH), sodium sulfide (Na_2S), and, to a lesser extent, soda ash (Na_2CO_3), phosphate, and ferrous sulfide (FeS).

The solubility of a particular compound will depend on the extent to which the electrostatic forces holding the ions of the compound together can be overcome. The solubility will change significantly with temperature; most metal compounds are more soluble as the temperature increases. Additionally, the solubility will be affected by the other constituents present in a waste. As a general rule, nitrates, chlorides, and sulfates are more soluble than hydroxides, sulfides, carbonates, and phosphates.

An important concept related to treatment of the soluble metal compounds is pH. This term provides a measure of the extent to which a solution contains either an excess of hydrogen or hydroxide ions. The pH scale ranges from 0 to 14, with 0 being the most acidic, 14 representing the highest alkalinity or hydroxide ion (OH^-) content, and 7.0 being neutral.

When hydroxide is used, as is often the case, to precipitate the soluble metal compounds, the pH is frequently monitored to ensure that sufficient treatment chemicals are added. It is important to point out

that pH is not a good measure of treatment chemical addition for compounds other than hydroxides; when sulfide is used, for example, facilities might use an oxidation-reduction potential meter (ORP) correlation to ensure that sufficient treatment chemical is used.

Following conversion of the relatively soluble metal compounds to metal precipitates, the effectiveness of chemical precipitation is a function of the physical removal, which usually relies on a settling process. A particle of a specific size, shape, and composition will settle at a specific velocity, as described by Stokes' Law. For a batch system, Stokes' Law is a good predictor of settling time because the pertinent particle parameters remain essentially constant. Nevertheless, in practice, settling time for a batch system is normally determined by empirical testing. For a continuous system, the theory of settling is complicated by factors such as turbulence, short-circuiting, and velocity gradients, increasing the importance of the empirical tests.

(3) Description of the chemical precipitation process. The equipment and instrumentation required for chemical precipitation varies depending on whether the system is batch or continuous. Both operations are discussed below; a schematic of the continuous system is shown in Figure 3-3.

For a batch system, chemical precipitation requires only a feed system for the treatment chemicals and a second tank where the waste can be treated and allowed to settle. When lime is used, it is generally added to the reaction tank in a slurry form. In a batch system, the supernate is usually analyzed before discharge, thus minimizing the need for instrumentation.

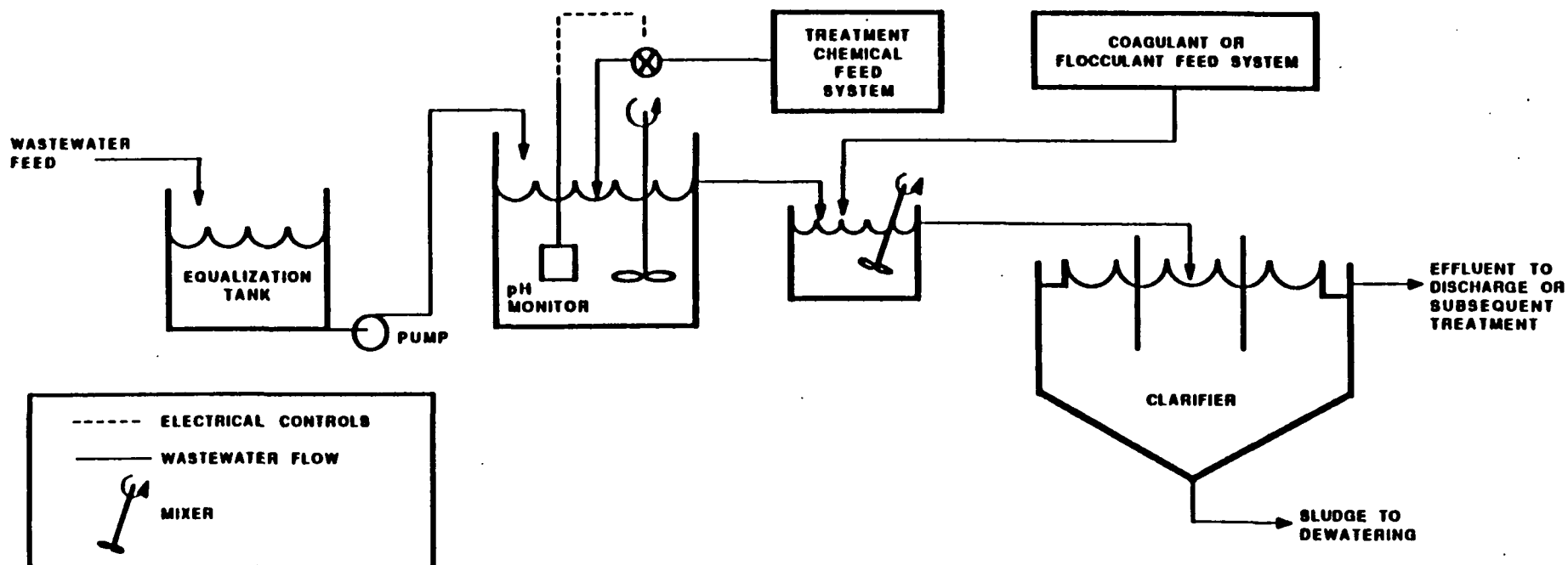


FIGURE 3-3 CONTINUOUS CHEMICAL PRECIPITATION

In a continuous system, additional tanks are necessary, along with the instrumentation to ensure that the system is operating properly. In this system, the first tank that the wastewater enters is referred to as an equalization tank. This is where the waste can be mixed in order to provide more uniformity, minimizing wide swings in the type and concentration of constituents being sent to the reaction tank. It is important to reduce the variability of the waste sent to the reaction tank because control systems inherently are limited with regard to the maximum fluctuations that can be managed.

Following equalization, the waste is pumped to a reaction tank where treatment chemicals are added; this is done automatically by using instrumentation that senses the pH of the system and then pneumatically adjusts the position of the treatment chemical feed valve so that the design pH value is achieved. Both the complexity and the effectiveness of the automatic control system will vary depending on the variation in the waste and the pH range that is needed to properly treat the waste.

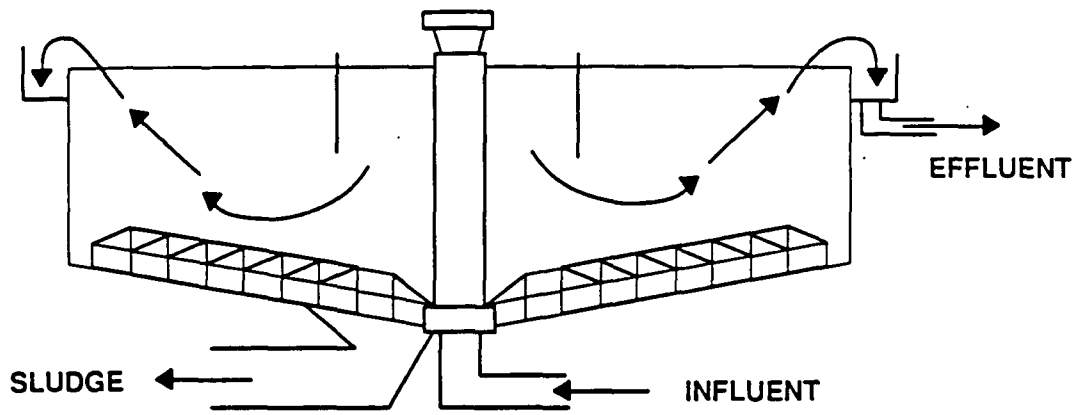
It is important that the reaction tank be designed to assure that the waste and treatment chemicals are dispersed throughout the tank; this ensures commingling of the reactant and the treatment chemicals. In addition, effective dispersion of the treatment chemicals throughout the tank is necessary to properly monitor and thereby control the amount of treatment chemicals added.

After the waste is reacted with the treatment chemical, it flows to a quiescent tank where the precipitate is allowed to settle and subsequently be removed. Settling can be chemically assisted through the

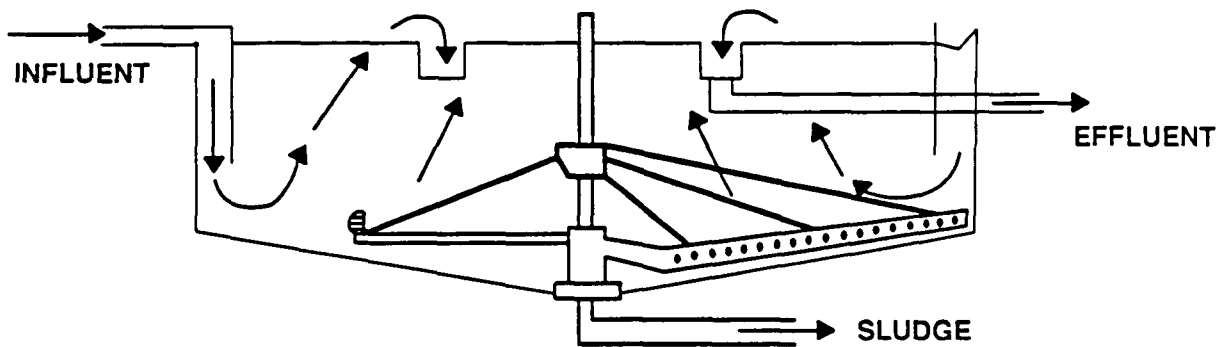
use of flocculating compounds. Flocculants increase the particle size and density of the precipitated solids, both of which increase the rate of settling. The particular flocculating agent that will best improve settling characteristics will vary depending on the particular waste; selection of the flocculating agent is generally accomplished by performing laboratory bench tests. Settling can be conducted in a large tank by relying solely on gravity or can be mechanically assisted through the use of a circular clarifier or an inclined separator. Schematics of the two separators are shown in Figures 3-4 and 3-5.

Filtration can be used for further removal of precipitated residuals both in cases where the settling system is underdesigned and in cases where the particles are difficult to settle. Polishing filtration is discussed in a separate technology section.

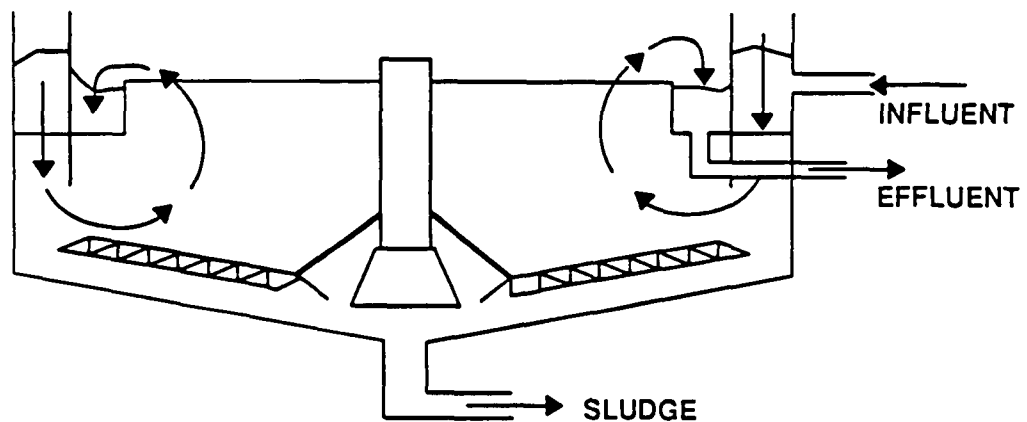
(4) Waste characteristics affecting performance. In determining whether chemical precipitation is likely to achieve the same level of performance on an untested waste as on a previously tested waste, the following waste characteristics will be examined: (a) the concentration and type of the metal(s) in the waste, (b) the concentration of total suspended solids (TSS), (c) the concentration of total dissolved solids (TDS), (d) whether the metal exists in the wastewater as a complex, and (e) the oil and grease content. These parameters affect the chemical reaction of the metal compound, the solubility of the metal precipitate, or the ability of the precipitated compound to settle.



CENTER FEED CLARIFIER WITH SCRAPER SLUDGE REMOVAL SYSTEM



RIM FEED - CENTER TAKEOFF CLARIFIER WITH HYDRAULIC SUCTION SLUDGE REMOVAL SYSTEM



RIM FEED - RIM TAKEOFF CLARIFIER

FIGURE 3-4 CIRCULAR CLARIFIERS

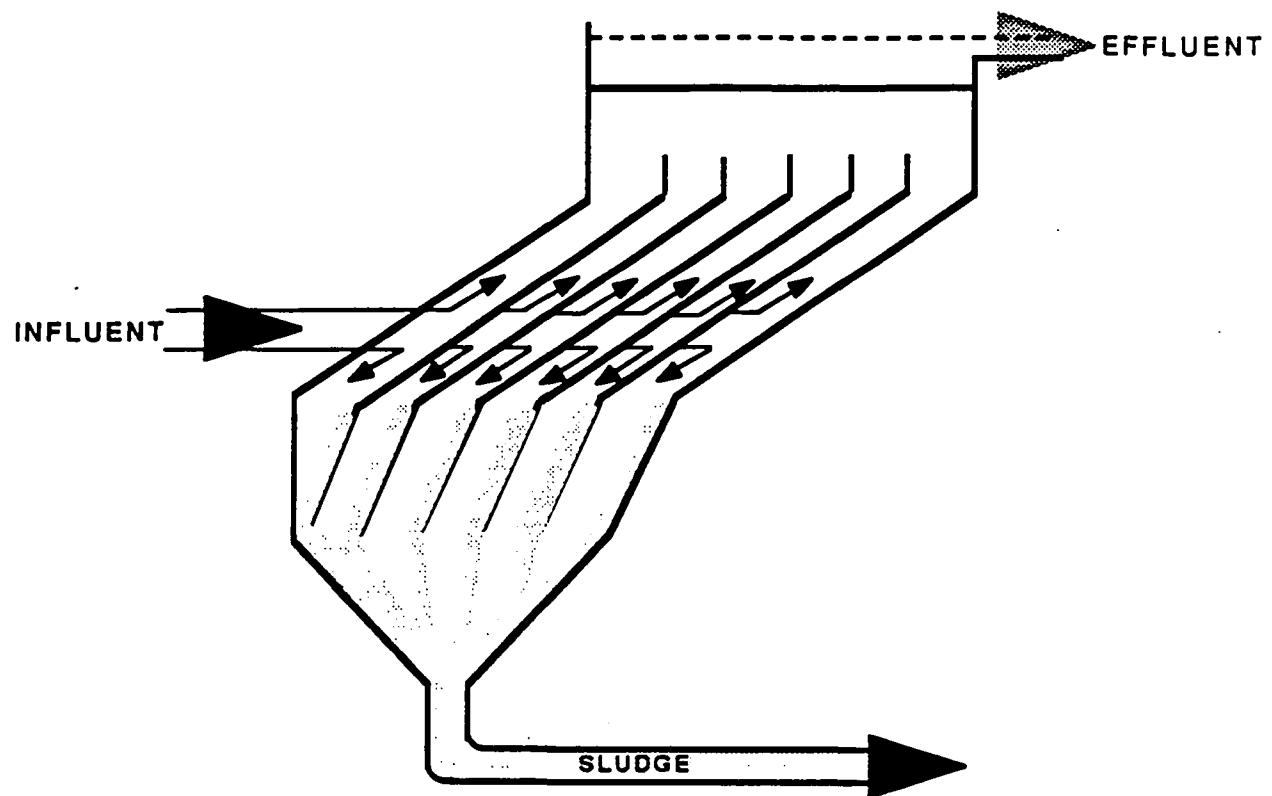


FIGURE 3-5
INCLINED PLATE SETTLER

(a) Concentration and type of metals. For most metals, there is a specific pH at which the metal hydroxide is least soluble. As a result, when a waste contains a mixture of many metals, it is not possible to operate a treatment system at a single pH that is optimal for the removal of all metals. The extent to which this affects treatment depends on the particular metals to be removed and their concentrations. An alternative can be to operate multiple precipitations, with intermediate settling, when the optimum pH occurs at markedly different levels for the metals present. The individual metals and their concentrations can be measured using EPA Method 6010.

(b) Concentration and type of total suspended solids (TSS). Certain suspended solid compounds are difficult to settle because of either their particle size or shape. Accordingly, EPA will evaluate this characteristic in assessing transfer of treatment performance. Total suspended solids can be measured by EPA Wastewater Test Method 160.2.

(c) Concentration of total dissolved solids (TDS). Available information shows that total dissolved solids can inhibit settling. The literature states that poor flocculation is a consequence of high TDS and shows that higher concentrations of total suspended solids are found in treated residuals. Poor flocculation can adversely affect the degree to which precipitated particles are removed. Total dissolved solids can be measured by EPA Wastewater Test Method 160.1.

(d) Complexed metals. Metal complexes consist of a metal ion surrounded by a group of other inorganic or organic ions or molecules (often called ligands). In the complexed form, the metals have a greater

solubility and, therefore, may not be as effectively removed from solution by chemical precipitation. EPA does not have an analytical method to determine the amount of complexed metals in the waste. The Agency believes that the best measure of complexed metals is to analyze for some common complexing compounds (or complexing agents) generally found in wastewater for which analytical methods are available. These complexing agents include ammonia, cyanide, and EDTA. The analytical method for cyanide is EPA Method 9010. The method for EDTA is ASTM Method D3113. Ammonia can be analyzed using EPA Wastewater Test Method 350.

(e) Oil and grease content. The oil and grease content of a particular waste directly inhibits the settling of the precipitate. Suspended oil droplets float in water and tend to suspend particles such as chemical precipitates that would otherwise settle out of the solution. Even with the use of coagulants or flocculants, the separation of the precipitate is less effective. Oil and grease content can be measured by EPA Method 9071.

(5) Design and operating parameters. The parameters that EPA will evaluate when determining whether a chemical precipitation system is well designed are: (a) design value for treated metal concentrations, as well as other characteristics of the waste used for design purposes (e.g., total suspended solids), (b) pH, (c) residence time, (d) choice of treatment chemical, and (e) choice of coagulant/flocculant. Below is an explanation of why EPA believes these parameters are important to a

design analysis; in addition, EPA explains why other design criteria are not included in EPA's analysis.

(a) Treated and untreated design concentrations. EPA pays close attention to the treated concentration the system is designed to achieve when determining whether to sample a particular facility. Since the system will seldom out-perform its design, EPA must evaluate whether the design is consistent with best demonstrated practice.

The untreated concentrations that the system is designed to treat are important in evaluating any treatment system. Operation of a chemical precipitation treatment system with untreated waste concentrations in excess of design values can easily result in poor performance.

(b) pH. The pH is important because it can indicate that sufficient treatment chemical (e.g., lime) is added to convert the metal constituents in the untreated waste to forms that will precipitate. The pH also affects the solubility of metal hydroxides and sulfides, and therefore directly impacts the effectiveness of removal. In practice, the design pH is determined by empirical bench testing, often referred to as "jar" testing. The temperature at which the "jar" testing is conducted is important in that it also affects the solubility of the metal precipitates. Operation of a treatment system at temperatures above the design temperature can result in poor performance. In assessing the operation of a chemical precipitation system, EPA prefers continuous data on the pH and periodic temperature conditions throughout the treatment period.

(c) Residence time. The residence time is important because it impacts the completeness of the chemical reaction to form the metal precipitate and, to a greater extent, the amount of precipitate that settles out of solution. In practice, it is determined by "jar" testing. For continuous systems, EPA will monitor the feed rate to ensure that the system is operated at design conditions. For batch systems, EPA will want information on the design parameter used to determine sufficient settling time (e.g., total suspended solids).

(d) Choice of treatment chemical. A choice must be made as to what type of precipitating agent (i.e., treatment chemical) will be used. The factor that most affects this choice is the type of metal constituents to be treated. Other design parameters, such as pH, residence time, and choice of coagulant/flocculant agents, are based on the selection of the treatment chemical.

(e) Choice of coagulant/flocculant. This is important because these compounds improve the settling rate of the precipitated metals and allow for smaller systems (i.e., lower retention time) to achieve the same degree of settling as a much larger system. In practice, the choice of the best agent and the required amount is determined by "jar" testing.

(f) Mixing. The degree of mixing is a complex assessment that includes, among other things, the energy supplied, the time the material is mixed, and the related turbulence effects of the specific size and shape of the tank. EPA will, however, consider whether mixing is provided and whether the type of mixing device is one that could be

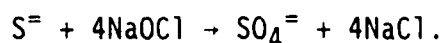
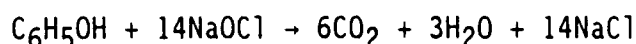
expected to achieve uniform mixing. For example, EPA may not use data from a chemical precipitation treatment system where an air hose was placed in a large tank to achieve mixing.

3.2.4 Chemical Oxidation

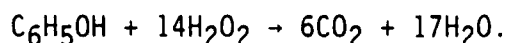
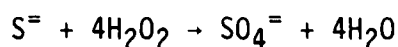
(1) Applicability and use of chemical oxidation. Chemical oxidation processes are used to oxidize a number of BDAT list organic compounds including phenol and some substituted phenols. In addition, this process is used to treat sulfide wastes by converting the sulfide to the essentially insoluble sulfate form. The parameters that affect selection of this technology include water content, filterable solids, and total organic carbon content. The term chemical oxidation, as used in this report, refers to the technology that is applicable only when treatment can be conducted at ambient or near ambient pressure and temperature conditions. When chemical oxidation is conducted at higher temperatures and pressures, the process is referred to as wet air oxidation. This latter technology is discussed separately. The processes described in this section also do not include the oxidation of cyanides by similar chemicals, which is also discussed separately.

(2) Underlying principles of operation. Some dissolved organic compounds or sulfides can be chemically oxidized to yield carbon dioxide, water, salts, or acids, and, in the case of sulfides, sulfates. The principal oxidants are hypochlorate or free chlorine, hydrogen peroxide, and chlorine dioxide. The reaction chemistry for each of these oxidants is discussed below.

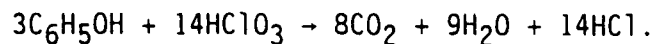
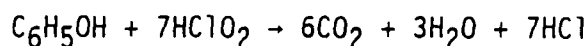
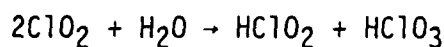
(a) Oxidation with hypochlorite or free chlorine. This type of oxidation is carried out using either sodium hypochlorite or free chlorine. The reaction is normally conducted under slightly alkaline conditions. Example reactions for the oxidation of phenol and sulfide are shown below.



(b) Peroxide oxidation. Peroxide also oxidizes the same constituents (intermediate) under similar conditions. The relevant reactions are:



(c) Chlorine dioxide oxidation. Chlorine dioxide also oxidizes the same pollutants under identical conditions. Chlorine dioxide first hydrolyzes to form a mixture of chlorous (HClO_2) and chloric acids (HClO_3). These acids act as the oxidants, as shown in the equations below.



(3) Description of the chemical oxidation process. Chemical oxidation can be accomplished by either a batch or a continuous process. For batch treatment, the wastewater is transferred to a reaction tank where the pH is adjusted and the oxidizing agent is added. In some cases, the tank may be heated to increase the reaction rate. For most operations, a slightly alkaline pH is used. It is important that the wastewater in the tank be well mixed for effective treatment to occur. After treatment, the wastewater is either directly discharged or transferred to another process for further treatment.

In the continuous process, automatic instrumentation may be used to control pH levels, reagent oxidation, and temperature. In both types of processes, typical retention times are in the 60- to 120-minute range.

(4) Waste characteristics affecting performance. In determining whether performance standards can be transferred from a previously tested waste to an untested waste, EPA will examine the following waste characteristics: (1) the concentration of other oxidizable contaminants and (2) the presence of metal salts.

(a) Concentration of organic oxidizable compounds. The presence of other oxidizable compounds in addition to the BDAT constituents of concern will increase the demand for oxidizing agents and hence will potentially reduce the effectiveness of the treatment process. As a surrogate for the amount of oxidizable organics present, EPA will analyze for total organic carbon (TOC).

(b) Concentrations of metal salts (oxidizable compounds). Metal salts, especially lead and silver salts, will react with the oxidizing agent(s) to form metal peroxides, chlorides, hypochlorites, and/or chlorates. Formation of these compounds can cause excessive consumption of oxidizing agents and potentially interfere with the effectiveness of treatment. Lead and silver salts can be analyzed by EPA Method 3050.

(5) Design and operating parameters. In assessing the effectiveness of the design and operation of a chemical oxidation system, the parameters that the Agency will examine are:

1. Retention time;
2. Type of oxidizing agent;
3. Mixing;
4. pH; and
5. Temperature.

(a) Retention time. The system must be designed to provide enough retention time to ensure complete oxidation. For a batch system, adequate retention time is provided by holding the treated batch until the reaction nears completion prior to discharge. The reaction typically requires from 1 to 2 hours to approach completion. The rate may be increased somewhat by increasing the temperature if the reaction tank is equipped with heating units. The tank size is determined by the amount of waste treated per batch and the amount of oxidizing agent added. For continuous systems, retention time is determined by the size of the tank and the process flow rates of the waste treated. To ensure that the system is operated at the design retention time, EPA will monitor the waste feed rate.

(b) Type of oxidizing agent. Several factors govern the choice of oxidizing agents. The amount of oxidizing agent required to treat a given amount of reducing compound will vary with the agent chosen. Enough oxidant must be added to ensure complete oxidation; the specific amount will depend on the type and chemistry of the reducing compounds in the waste. Theoretically, the amount of oxidizing agent to be added can be computed from process stoichiometry; in practice, a small excess of oxidant should be used. In assessing the effectiveness of any chemical oxidation system, EPA would want to know how a facility determines the amount of oxidant to be added, as well as how the facility ensures that the particular addition rate is maintained.

(c) Mixing. Process tanks must be equipped with mixers to ensure that there is maximum contact between the reducing solution and the oxidizing agent. Proper mixing also limits the production of any solid precipitates from side reactions that may resist oxidation. In addition, mixing provides an even distribution of the tank contents and a homogeneous pH throughout the waste, thereby improving oxidation of wastewater constituents. The quantifiable degree of mixing is a complex assessment that includes the energy supplied, the time the material is mixed, and the related turbulence effects of the specific size and shape of the tank. EPA will, however, evaluate the degree of mixing qualitatively by considering whether mixing is provided and whether the type of mixing device is one that could be expected to achieve uniform mixing.

(d) pH. Operation at the optimal pH will maximize the chemical oxidation by keeping the ions in solution and limiting the formation of undesirable precipitates. The pH in batch processes should be monitored at regular intervals during the reaction. The pH is controlled by the addition of caustic, lime, or acid to the solution. In most cases, a slightly alkaline pH is used. In a few cases involving the use of free chlorine, slightly acidic pH values may be selected. In order to ensure that the proper pH is maintained during treatment, EPA will continuously monitor the pH.

(e) Temperature. Temperature is important because it affects the rate of reaction and the solubility of the oxidizing agent. As the temperature is increased, the required reaction time is reduced and the solubility of the oxidizing agent will, in most instances, be increased. EPA will monitor temperature during the treatment period to ensure that the design value is achieved.

4. PERFORMANCE DATA BASE

This section discusses the available performance data associated with the demonstrated technologies for K071 waste. Performance data include the constituent concentrations in untreated and treated waste samples, the operating data collected during treatment of the sampled waste, design values for the treatment technology, and data on waste characteristics that affect performance. EPA has presented all such data to the extent that they are available, in tables found at the end of this section.

EPA's use of these data in determining the technology that represents BDAT, and for developing treatment standards, is described in Sections 5 and 7, respectively.

4.1 Nonwastewater

At Plant A, the Agency collected seven sets of untreated K071 waste and treated nonwastewater samples from a treatment system that consisted of acid leaching, chemical oxidation, and sludge dewatering/acid washing (as described in Section 3.2.1). The Agency also collected one set of samples from treatment by a one-step acid leaching (percolation) treatment process (see Section 3.2.1(3)). These data (designated as Plant A.1 data) are presented in Tables 4-1 and 4-2. These data show, along with design and operating information, the total and TCLP leachate concentrations of metals in both the untreated and treated matrices. Note that the untreated concentration of mercury in the waste undergoing treatment by one-step acid leaching was sufficiently low that EPA does

not believe a performance evaluation would be meaningful. The untreated TCLP leachate concentration for mercury was 0.0006 mg/l.

Industry provided the Agency with two additional groups of data for treatment of the K071 waste using the first treatment system described above. One group of data is also from Plant A (designated as Plant A.2 data) and consists of 379 data points for EP leachate concentrations of mercury in the treated waste. The other group of data (designated as Plant B data) consists of EP leachate results for mercury from 19 samples of treated waste; the total concentration of mercury was measured in four of the samples. These two groups of data are presented in Tables 4-3 and 4-4.

Additional data were submitted by industry for treatment of K071 nonwastewater by sludge dewatering/water washing. Table 4-5 presents 12 data sets submitted by Plant C, showing total and EP leachate concentrations of metals (2 of the data sets indicate TCLP leachate concentrations) in the treated residuals. Table 4-6 presents 24 data sets of total and EP leachate concentrations of metals in the treated residuals from Plant D. Another 232 data points showing EP leachate concentrations of mercury in the treated waste were submitted by Plant E. These data are shown in Table 4-7.

4.2 Wastewater

The Agency collected three samples each of untreated and treated waste from treatment of K071 wastewater in a sulfide precipitation and filtration treatment system at Plant A. The data from these samples are presented in Table 4-8.

Table 4-1 Acid Leaching, Chemical Oxidation, and Sludge Dewatering/Acid Washing Data
Collected by EPA at Plant A (Plant A.1 Data)

Sample Set #1

Constituent	Concentration			
	Untreated waste		Treated waste	
	Total (mg/l)	TCLP (mg/l)	Total (mg/kg)	TCLP (mg/l)
Barium	0.57	0.31	3.3	0.12
Cadmium	<0.3	<0.06	<1.5	0.006
Copper	<0.8	<0.16	<4.0	0.06
Lead	<6.6	<1.3	<33	2.0
Mercury	17.0	0.44	2.7	0.0003
Nickel	4.87	0.54	24	0.08
Thallium	12.2	<1.7	62	0.25
Zinc	2.29	0.11	5.4	0.21

Note: Design and operating parameters are as follows:

Parameter	Design value	Operating value
Acidification reactor pH	2.5 - 3.0	2.94
Hypochlorite reactor pH	6.5	6.4
Hypochlorite reactor residence time	> 0.05 hr	0.25 hr
Filter vacuum	> 5.0 in Hg	5.0 in Hg

Reference: USEPA 1988a. Tables 3-1 and 5-2.

Table 4-1 (Continued)

Sample Set #2

Constituent	Concentration			
	Untreated waste		Treated waste	
	Total (mg/l)	TCLP (mg/l)	Total (mg/kg)	TCLP (mg/l)
Barium	0.57	0.31	3.2	0.13
Cadmium	<0.3	<0.06	<1.5	0.04
Copper	<0.8	<0.16	<4.0	<0.08
Lead	<6.6	<1.32	<33	0.84
Mercury	17.0	0.44	4.8	<0.0002
Nickel	4.87	0.54	23	<0.13
Thallium	12.2	<1.7	51	<0.86
Zinc	2.29	0.11	4.7	0.18

Note: Design and operating parameters are as follows:

Parameter	Design value	Operating value
Acidification reactor pH	2.5 - 3.0	2.95
Hypochlorite reactor pH	6.5	6.4
Hypochlorite reactor residence time	> 0.05 hr	0.25 hr
Filter vacuum	> 5.0 in Hg	5.0 in Hg

Reference: USEPA 1988a. Tables 3-1 and 5-3.

Table 4-1 (Continued)

Sample Set #3

Constituent	Concentration			
	Untreated waste		Treated waste	
	Total (mg/l)	TCLP (mg/l)	Total (mg/kg)	TCLP (mg/l)
Barium	0.814	0.22	2.7	0.18
Cadmium	<0.15	<0.3	<1.5	0.13
Copper	1.19	<0.8	<4.0	<0.16
Lead	<3.3	<6.6	<33	<1.3
Mercury	22.1	20	1.8	2.0
Nickel	3.15	<1.3	21	<0.26
Thallium	7.74	<8.6	51	<1.7
Zinc	3.18	0.92	3.9	0.25

Note: Design and operating parameters are as follows:

Parameter	Design value	Operating value
Acidification reactor pH	2.5 - 3.0	2.93
Hypochlorite reactor pH	6.5	6.4
Hypochlorite reactor residence time	> 0.05 hr	0.38 hr
Filter vacuum	> 5.0 in Hg	7.0 in Hg

Reference: USEPA 1988a. Tables 3-1 and 5-4.

Table 4-1 (Continued)

Sample Set #4

Constituent	Concentration			
	Untreated waste		Treated waste	
	Total (mg/l)	TCLP (mg/l)	Total (mg/kg)	TCLP (mg/l)
Barium	0.814	0.22	2.7	0.16
Cadmium	<0.15	<0.3	<3.0	<0.01
Copper	1.19	<0.8	<4.0	0.05
Lead	<3.3	<6.6	<33	0.33
Mercury	22.1	20	1.7	0.0002
Nickel	3.15	<1.3	20	0.13
Thallium	7.74	<8.6	<43	<0.43
Zinc	3.18	0.92	3.1	0.28

Note: Design and operating parameters are as follows:

Parameter	Design value	Operating value
Acidification reactor pH	2.5 - 3.0	2.93
Hypochlorite reactor pH	6.5	6.4
Hypochlorite reactor residence time	> 0.05 hr	0.36 hr
Filter vacuum	> 5.0 in Hg	7.0 in Hg

Reference: USEPA 1988a. Tables 3-1 and 5-5.

Table 4-1 (Continued)

Sample Set #5

Constituent	Concentration			
	Untreated waste		Treated waste	
	Total (mg/l)	TCLP (mg/l)	Total (mg/kg)	TCLP (mg/l)
Barium	0.814	0.22	2.4	0.16
Cadmium	<0.15	<0.3	<1.5	0.003
Copper	1.19	<0.8	<4.0	0.05
Lead	<3.3	<6.6	<33	0.16
Mercury	22.1	20	1.2	0.0005
Nickel	3.15	<1.3	21	0.07
Thallium	7.74	<8.6	43	0.26
Zinc	3.18	0.92	5.0	0.23

Note: Design and operating parameters are as follows:

Parameter	Design value	Operating value
Acidification reactor pH	2.5 - 3.0	2.94
Hypochlorite reactor pH	6.5	6.4
Hypochlorite reactor residence time	> 0.05 hr	0.46 hr
Filter vacuum	> 5.0 in Hg	7.0 in Hg

Reference: USEPA 1988a. Tables 3-1 and 5-6.

Table 4-1 (Continued)

Sample Set #6

Constituent	Concentration			
	Untreated waste		Treated waste	
	Total (mg/l)	TCLP (mg/l)	Total (mg/kg)	TCLP (mg/l)
Barium	1.1	0.34	2.4	0.14
Cadmium	<1.5	<0.06	<1.5	<0.01
Copper	<4.0	<0.16	<4.0	0.05
Lead	<33	<1.3	<33	<0.33
Mercury	20.6	2.1	1.8	0.0016
Nickel	<6.5	0.31	22	0.11
Thallium	<43	<1.7	<43	<0.43
Zinc	3.05	0.37	5.3	0.41

Note: Design and operating parameters are as follows:

Parameter	Design value	Operating value
Acidification reactor pH	2.5 - 3.0	2.92
Hypochlorite reactor pH	6.5	6.4
Hypochlorite reactor residence time	> 0.05 hr	0.30 hr
Filter vacuum	> 5.0 in Hg	11 in Hg

Reference: USEPA 1988a. Tables 3-1 and 5-7.

Table 4-1 (Continued)

Sample Set #7

Constituent	Concentration			
	Untreated waste		Treated waste	
	Total (mg/l)	TCLP (mg/l)	Total (mg/kg)	TCLP (mg/l)
Barium	1.1	0.34	3.1	0.16
Cadmium	<1.5	<0.06	<1.5	<0.003
Copper	<4.0	<0.16	<4.0	0.05
Lead	<33	<1.3	<33	0.07
Mercury	20.6	2.1	1.7	<0.0002
Nickel	<6.5	0.31	24	0.09
Thallium	<43	<1.7	<43	0.18
Zinc	3.05	0.37	5.3	0.34

Note: Design and operating parameters are as follows:

Parameter	Design value	Operating value
Acidification reactor pH	2.5 - 3.0	2.91
Hypochlorite reactor pH	6.5	6.4
Hypochloride reactor residence time	> 0.05 hr	0.31 hr
Filter vacuum	> 5.0 in Hg	11 in Hg

Reference: USEPA 1988a. Tables 3-1 and 5-8.

Table 4-2 Acid Leaching (Percolation) Data Collected by EPA
at Plant A (Plant A.1 Data)

Sample Set #1

Constituent	Concentration			
	Untreated waste		Treated waste	
	Total (mg/l)	TCLP (mg/l)	Total (mg/kg)	TCLP (mg/l)
Barium	1.4	0.2	2.2	0.18
Cadmium	<1.5	0.09	<1.5	<0.06
Copper	<4.0	<0.16	<4.0	0.16
Lead	<33	<1.3	<33	1.3
Mercury	1.1	0.0006	1.6	0.0006
Nickel	7.9	<0.26	<6.5	0.46
Silver	<2.5	0.45	<2.5	<0.25
Thallium	<43	<1.7	<43	<1.7
Zinc	2.5	0.42	1.8	0.18

Note: Design and operating parameters are as follows:

Parameter	Design value	Operating value
Acidification pH	3.0	3.0
Retention time for acid leaching	>3.0 hrs	1.0 hr

Reference: USEPA 1988a. Tables 3-3 and 5-12.

Table 4-3 Acid Leaching, Chemical Oxidation, and Sludge Dewatering/Acid Washing Data
Submitted by Plant A (Plant A.2 Data)

Sample no.	Treated mercury concentration EP (mg/l)	Disposition code ^a	Operating information ^b			
			Date sampled	Acidification reactor pH	Hypochlorite reactor pH	Filter vacuum (in Hg)
1	0.018	3	11/18/86	2.9-3.9	6.4	11
2	0.056	3	11/21/86	2.9	6.6	8
3	0.008	1	11/23/86	2.9	6.7	12
4	0.025	3	11/24/86	3.0-4.4	6.4-6.9	16-19
5	<0.002	1	11/25/86	2.0	6.2	10-14
6	<0.002	1	11/25/86	3.0-3.1	6.4-6.5	9-10
7	0.007	1	11/26/86	3.0	6.6	5
8	0.002	1	11/27/86	3.0	6.4	7
9	<0.002	1	11/28/86	3.0-3.1	6.4-6.6	7-11
10	0.012	1	11/29/86	3.0	6.4	8
11	0.003	1	11/30/86	3.2	6.6	5
12	0.004	1	11/30/86	3.3	6.4	10
13	0.002	1	12/01/86	3.4	6.4-6.6	8
14	<0.002	1	12/04/86	3.1-3.2	6.5-6.6	11-14
15	<0.002	1	12/05/86	2.7-3.0	6.4	8-9
16	<0.002	1	12/06/86	3.1	6.4	15-17
17	0.001	1	12/09/86	3.0-3.1	6.4	9-10
18	0.003	1	12/09/86	3.1	6.4	10-12
19	<0.001	1	12/10/86	3.0	6.4	8
20	<0.002	1	12/11/86	3.1	6.2-6.4	5-8
21	<0.002	1	12/12/86	3.5-3.8	6.4-6.6	5-7
22	<0.002	1	12/13/86	3.2-3.3	6.5-6.6	6-8
23	<0.002	1	12/14/86	3.8	6.4	8
24	<0.002	1	12/15/86	2.8-3.4	6.6	6-9
25	<0.001	1	12/17/86	3.2	6.6	8-12
26	<0.001	1	12/17/86	3.2	6.6	10
27	<0.002	1	12/18/86	3.0-3.3	6.6	8-10
28	<0.002	1	12/21/86	3.3	6.6	10
29	<0.002	1	12/21/86	3.3	6.6	11
30	<0.001	1	12/23/86	3.3	6.5	6-7
31	0.002	1	12/25/86	3.1-3.2	6.5-6.6	8-10
32	<0.001	1	12/25/86	2.8-3.2	6.2-6.5	9-12
33	<0.001	1	12/26/86	3.2	6.5-6.6	8-10
34	<0.001	1	12/27/86	2.6-3.3	6.5	6-10
35	<0.001	1	12/28/86	3.1-3.3	6.4-6.5	8-9
36	<0.001	1	12/29/86	3.1-3.2	5.8-6.5	10-14

^aDisposition codes as defined by the facility are as follows: (1) transported to sanitary landfill for disposal; (2) reanalyzed because of suspected contamination; (3) returned to treatment system for reprocessing; and (4) transported to licensed hazardous waste landfill for disposal.

^bThe design values associated with these operating data are presented in Table 4-1.

Table 4-3 (Continued)

Sample no.	Treated mercury concentration EP (mg/l)	Disposition code ^a	Operating information ^b			
			Date sampled	Acidification reactor pH	Hypochlorite reactor pH	Filter vacuum (in Hg)
37	0.001	1	12/31/86	3.2	6.4	9-11
38	0.002	1	01/01/87	3.9	-	6
39	0.001	1	01/01/87	3.3	6.4	9
40	0.002	1	01/04/87	3.4	6.5	8
41	0.001	1	01/04/87	3.3	6.4	10
42	0.009	1	01/06/87	3.4-3.6	6.4-6.5	8
43	<0.001	1	01/07/87	3.2-3.3	6.5	8
44	0.012	1	01/08/87	4.6	-	8
45	0.001	1	01/09/87	3.2	6.4-6.5	8
46	<0.001	1	01/11/87	3.1-3.2	6.4-6.5	6-14
47	0.015	2	01/12/87	3.2	6.5	16-17
48	0.016	2	01/12/87	-	-	-
49	0.027	3	01/12/87	-	-	-
50	0.028	2	01/15/87	3.2-3.3	6.4-6.5	8-11
51	0.026	3	01/15/87	-	-	-
52	<0.001	1	01/16/87	3.3	6.4	8-10
53	<0.001	1	01/17/87	3.2-3.4	6.4	7-8
54	<0.001	1	01/18/87	3.3-3.8	6.5	5-10
55	0.001	1	01/19/87	3.1-3.2	6.5	8-9
56	<0.001	1	01/20/87	3.0-3.2	6.4	6-7
57	<0.001	1	01/22/87			
58	<0.001	1	01/25/87			
59	<0.001	1	01/25/87			
60	<0.001	1	01/27/87	(Operating data were not submitted for the remaining treated data points.)		
61	<0.001	1	01/28/87			
62	<0.001	1	02/01/87			
63	0.001	1	02/01/87			
64	<0.001	1	01/29/87			
65	<0.001	1	02/03/87			
66	<0.001	1	02/05/87			
67	<0.001	1	02/08/87			
68	<0.001	1	02/08/87			
69	<0.001	1	02/09/87			
70	<0.001	1	02/10/87			
71	<0.001	1	02/12/87			
72	<0.001	1	02/15/87			
73	<0.001	1	02/15/87			
74	0.001	1	02/16/87			
75	0.004	1	02/18/87			
76	<0.001	1	02/18/87			
77	0.001	1	02/22/87			

^aDisposition codes as defined by the facility are as follows: (1) transported to sanitary landfill for disposal; (2) reanalyzed because of suspected contamination; (3) returned to treatment system for reprocessing; and (4) transported to licensed hazardous waste landfill for disposal.

^bThe design values associated with these operating data are presented in Table 4-1.

Table 4-3 (Continued)

Sample no.	Treated mercury concentration EP (mg/l)	Disposition code ^a	Operating information ^b			
			Date sampled	Acidification reactor pH	Hypochlorite reactor pH	Filter vacuum (in Hg)
78	0.001	1	02/22/87			
79	0.004	1	02/24/87			
80	<0.001	1	02/25/87			
81	<0.001	1	03/01/87			
82	<0.001	1	02/28/87			
83	0.018	2	03/02/87			
84	0.018	3	03/02/87			
85	0.008	1	03/03/87			
86	<0.001	1	03/04/87			
87	0.001	1	03/05/87			
88	0.001	1	03/07/87			
89	0.007	1	03/08/87			
90	0.017	2	03/08/87			
91	<0.001	1	03/08/87			
92	0.006	1	03/10/87			
93	0.005	1	03/11/87			
94	0.009	1	03/14/87			
95	0.001	1	03/15/87			
96	0.002	1	03/13/87			
97	<0.001	1	03/17/87			
98	0.002	1	03/18/87			
99	0.002	1	03/19/87			
100	0.004	1	03/22/87			
101	0.002	1	03/22/87			
102	0.002	1	03/24/87			
103	0.001	1	03/26/87			
104	0.001	1	03/29/87			
105	0.001	1	03/30/87			
106	0.005	1	04/01/87			
107	0.005	1	04/03/87			
108	0.003	1	04/05/87			
109	0.003	1	04/05/87			
110	0.002	1	04/07/87			
111	<0.001	1	04/08/87			
112	<0.001	1	04/10/87			
113	<0.001	1	04/11/87			
114	<0.001	1	04/12/87			
115	0.001	1	04/13/87			
116	<0.001	1	04/18/87			
117	<0.001	1	04/17/87			
118	<0.001	1	04/16/87			
119	<0.001	1	04/16/87			

^aDisposition codes as defined by the facility are as follows: (1) transported to sanitary landfill for disposal; (2) reanalyzed because of suspected contamination; (3) returned to treatment system for reprocessing; and (4) transported to licensed hazardous waste landfill for disposal.

^bThe design values associated with these operating data are presented in Table 4-1.

Table 4-3 (Continued)

Sample no.	Treated mercury concentration EP (mg/l)	Disposition code ^a	Operating information ^b			
			Date sampled	Acidification reactor pH	Hypochlorite reactor pH	Filter vacuum (in Hg)
120	0.001	1	04/20/87			
121	0.017	2	04/22/87			
122	<0.001	1	04/22/87			
123	0.003	1	04/23/87			
124	0.006	1	04/24/87			
125	<0.001	1	04/25/87			
126	0.002	1	04/28/87			
127	<0.001	1	04/30/87			
128	<0.001	1	05/02/87			
129	0.002	1	05/03/87			
130	<0.001	1	05/05/87			
131	<0.001	1	05/06/87			
132	<0.001	1	05/07/87			
133	0.001	1	05/08/87			
134	<0.001	1	05/12/87			
135	0.001	1	05/13/87			
136	<0.001	1	05/14/87			
137	<0.001	1	05/16/87			
138	<0.001	1	05/18/87			
139	<0.001	1	05/20/87			
140	0.003	1	05/21/87			
141	0.003	1	05/23/87			
142	0.001	1	05/25/87			
143	0.006	1	05/26/87			
144	0.003	1	05/27/87			
145	<0.001	1	05/29/87			
146	0.001	1	05/30/87			
147	<0.001	1	06/01/87			
148	0.012	1	06/02/87			
149	<0.001	1	06/04/87			
150	<0.002	1	06/06/87			
151	0.003	1	06/08/87			
152	0.018	2	06/09/87			
153	0.060	3	06/09/87			
154	0.031	3	06/10/87			
155	0.002	1	06/14/87			
156	<0.001	1	06/16/87			
157	<0.001	1	06/17/87			
158	<0.001	1	06/19/87			

^aDisposition codes as defined by the facility are as follows: (1) transported to sanitary landfill for disposal; (2) reanalyzed because of suspected contamination; (3) returned to treatment system for reprocessing; and (4) transported to licensed hazardous waste landfill for disposal.

^bThe design values associated with these operating data are presented in Table 4-1.

Table 4-3 (Continued)

Sample no.	Treated mercury concentration EP (mg/l)	Disposition code ^a	Operating information ^b			
			Date sampled	Acidification reactor pH	Hypochlorite reactor pH	Filter vacuum (in Hg)
159	<0.001	1	06/21/87			
160	0.001	1	06/23/87			
161	0.060	2	06/24/87			
162	0.031	3	06/24/87			
163	0.021	3	06/25/87			
164	0.011	1	06/26/87			
165	<0.001	1	06/28/87			
166	<0.001	1	06/29/87			
167	0.016	2	07/01/87			
168	0.008	1	06/30/87			
169	0.007	1	07/04/87			
170	<0.001	1	07/05/87			
171	<0.001	1	07/05/87			
172	0.013	2	07/06/87			
173	0.032	3	07/07/87			
174	0.017	2	07/08/87			
175	0.006	1	07/08/87			
176	0.007	1	07/08/87			
177	0.001	1	07/09/87			
178	<0.001	1	07/12/87			
179	0.021	2	07/11/87			
180	0.004	1	07/11/87			
181	0.008	1	07/13/87			
182	0.005	1	07/14/87			
183	0.003	1	07/19/87			
184	0.001	1	07/21/87			
185	0.005	1	07/22/87			
186	0.007	1	07/24/87			
187	0.002	1	07/25/87			
188	0.040	2	07/26/87			
189	0.010	1	07/26/87			
190	0.001	1	07/28/87			
191	0.008	1	08/01/87			
192	0.005	1	08/02/87			
193	0.012	1	08/04/87			
194	0.002	1	08/05/87			
195	0.002	1	08/07/87			
196	0.028	2	08/09/87			
197	0.040	4	08/09/87			

^aDisposition codes as defined by the facility are as follows: (1) transported to sanitary landfill for disposal; (2) reanalyzed because of suspected contamination; (3) returned to treatment system for reprocessing; and (4) transported to licensed hazardous waste landfill for disposal.

^bThe design values associated with these operating data are presented in Table 4-1.

Table 4-3 (Continued)

Sample no.	Treated mercury concentration EP (mg/l)	Disposition code ^a	Date sampled	Operating information ^b		
				Acidification reactor pH	Hypochlorite reactor pH	Filter vacuum (in Hg)
198	0.022	2	08/12/87			
199	0.011	1	08/12/87			
200	0.240	4	08/14/87			
201	0.032	4	08/17/87			
202	0.031	4	08/23/87			
203	0.014	4	08/23/87			
204	0.003	1	08/24/87			
205	0.003	1	08/25/87			
206	0.012	1	08/24/87			
207	0.008	1	08/17/87			
208	0.002	1	08/27/87			
209	0.007	1	08/27/87			
210	0.005	1	09/06/87			
211	0.003	1	09/07/87			
212	0.012	1	09/05/87			
213	0.004	1	09/09/87			
214	0.004	1	09/09/87			
215	<0.001	1	09/10/87			
216	0.010	1	09/11/87			
217	<0.001	1	09/12/87			
218	0.002	1	09/13/87			
219	0.150	4	09/14/87			
220	0.010	1	09/15/87			
221	0.010	1	09/14/87			
222	0.005	1	09/17/87			
223	0.002	1	09/18/87			
224	0.002	1	09/19/87			
225	0.002	1	09/20/87			
226	0.005	1	09/20/87			
227	0.014	2	09/20/87			
228	0.001	1	09/20/87			
229	0.003	1	09/21/87			
230	0.068	4	09/21/87			
231	0.003	1	09/22/87			
232	<0.001	1	09/23/87			
233	0.009	1	09/25/87			
234	0.009	1	09/28/87			
235	0.005	1	10/01/87			
236	0.005	1	10/03/87			

^aDisposition codes as defined by the facility are as follows: (1) transported to sanitary landfill for disposal; (2) reanalyzed because of suspected contamination; (3) returned to treatment system for reprocessing; and (4) transported to licensed hazardous waste landfill for disposal.

^bThe design values associated with these operating data are presented in Table 4-1.

Table 4-3 (Continued)

Sample no.	Treated mercury concentration EP (mg/l)	Disposition code ^a	Operating information ^b			
			Date sampled	Acidification reactor pH	Hypochlorite reactor pH	Filter vacuum (in Hg)
237	0.003	1	10/04/87			
238	0.002	1	10/05/87			
239	0.008	1	10/09/87			
240	0.002	1	10/10/87			
241	0.008	1	10/11/87			
242	0.032	4	10/15/87			
243	0.012	1	10/18/87			
244	0.011	1	10/12/87			
245	0.003	1	10/17/87			
246	0.006	1	10/19/87			
247	0.028	4	10/20/87			
248	0.003	1	10/22/87			
249	0.001	1	10/24/87			
250	0.006	1	10/25/87			
251	<0.001	1	10/26/87			
252	<0.001	1	10/27/87			
253	<0.001	1	10/28/87			
254	0.001	1	10/28/87			
255	0.003	1	10/30/87			
256	0.006	1	11/01/87			
257	0.002	1	10/30/87			
258	0.001	1	10/31/87			
259	0.010	1	11/02/87			
260	0.006	1	10/21/87			
261	0.005	1	10/28/87			
262	0.011	1	11/03/87			
263	0.007	1	11/04/87			
264	0.011	1	11/05/87			
265	0.002	1	11/08/87			
266	0.012	1	11/07/87			
267	0.004	1	11/09/87			
268	0.021	2	11/10/87			
269	0.005	1	11/10/87			
270	0.003	1	11/11/87			
271	0.026	2	11/11/87			
272	0.009	1	11/11/87			
273	0.004	1	11/15/87			
274	0.004	1	11/15/87			
275	0.016	2	11/14/87			

^aDisposition codes as defined by the facility are as follows: (1) transported to sanitary landfill for disposal; (2) reanalyzed because of suspected contamination; (3) returned to treatment system for reprocessing; and (4) transported to licensed hazardous waste landfill for disposal.

^bThe design values associated with these operating data are presented in Table 4-1.

Table 4-3 (Continued)

Sample no.	Treated mercury concentration EP (mg/l)	Disposition code ^a	Operating information ^b			
			Date sampled	Acidification reactor pH	Hypochlorite reactor pH	Filter vacuum (in Hg)
276	0.008	1	11/14/87			
277	0.002	1	11/16/87			
278	0.001	1	11/17/87			
279	<0.001	1	11/14/87			
280	<0.001	1	11/18/87			
281	<0.001	1	11/19/87			
282	0.001	1	11/20/87			
283	0.006	1	11/21/87			
284	0.004	1	11/22/87			
285	0.010	1	11/23/87			
286	0.002	1	11/24/87			
287	0.003	1	11/26/87			
288	0.004	1	11/26/87			
289	<0.001	1	11/29/87			
290	<0.001	1	11/29/87			
291	<0.001	1	11/30/87			
292	0.001	1	11/30/87			
293	<0.001	1	12/01/87			
294	<0.001	1	12/03/87			
295	<0.001	1	12/04/87			
296	<0.001	1	12/06/87			
297	<0.001	1	12/07/87			
298	<0.001	1	12/08/87			
299	<0.001	1	12/09/87			
300	0.008	1	12/10/87			
301	<0.001	1	12/11/87			
302	0.001	1	12/12/87			
303	0.008	1	12/13/87			
304	0.001	1	12/14/87			
305	0.001	1	12/15/87			
306	0.003	1	12/15/87			
307	<0.001	1	12/16/87			
308	0.002	1	12/17/87			
309	<0.001	1	12/20/87			
310	<0.001	1	12/19/87			
311	<0.001	1	12/21/87			
312	<0.001	1	12/22/87			
313	0.002	1	12/27/87			
314	0.008	1	12/25/87			

^aDisposition codes as defined by the facility are as follows: (1) transported to sanitary landfill for disposal; (2) reanalyzed because of suspected contamination; (3) returned to treatment system for reprocessing; and (4) transported to licensed hazardous waste landfill for disposal.

^bThe design values associated with these operating data are presented in Table 4-1.

Table 4-3 (Continued)

Sample no.	Treated mercury concentration EP (mg/l)	Disposition code ^a	Operating information ^b			
			Date sampled	Acidification reactor pH	Hypochlorite reactor pH	Filter vacuum (in Hg)
315	0.003	1	12/26/87			
316	0.005	1	12/28/87			
317	<0.001	1	12/30/87			
318	<0.001	1	12/30/87			
319	<0.001	1	01/02/88			
320	<0.001	1	01/04/88			
321	0.004	1	01/05/88			
322	0.001	1	01/07/88			
323	0.002	1	01/10/88			
324	0.001	1	01/11/88			
325	<0.001	1	01/12/88			
326	<0.001	1	01/13/88			
327	0.001	1	01/16/88			
328	0.002	1	01/15/88			
329	<0.001	1	01/18/88			
330	0.002	1	01/20/88			
331	<0.001	1	01/21/88			
332	0.004	1	01/22/88			
333	0.004	1	01/24/88			
334	<0.001	1	01/25/88			
335	0.500	3	01/26/88			
336	0.001	1	01/28/88			
337	0.001	1	01/30/88			
338	<0.001	1	01/28/88			
339	<0.001	1	02/01/88			
340	<0.001	1	02/02/88			
341	<0.001	1	02/03/88			
342	<0.001	1	02/05/88			
343	0.001	1	02/07/88			
344	0.001	1	02/07/88			
345	0.001	1	02/08/88			
346	0.001	1	02/10/88			
347	<0.001	1	02/11/88			
348	0.001	1	02/12/88			
349	0.001	1	02/13/88			
350	<0.001	1	02/15/88			
351	0.003	1	02/16/88			
352	<0.001	1	02/17/88			
353	<0.001	1	02/18/88			

^aDisposition codes as defined by the facility are as follows: (1) transported to sanitary landfill for disposal; (2) reanalyzed because of suspected contamination; (3) returned to treatment system for reprocessing; and (4) transported to licensed hazardous waste landfill for disposal.

^bThe design values associated with these operating data are presented in Table 4-1.

Table 4-3 (Continued)

Sample no.	Treated mercury concentration EP (mg/l)	Disposition code ^a	Operating information ^b			
			Date sampled	Acidification reactor pH	Hypochlorite reactor pH	Filter vacuum (in Hg)
354	0.004	1	02/21/88			
355	0.008	1	02/20/88			
356	0.001	1	02/19/88			
357	0.001	1	02/23/88			
358	<0.001	1	02/24/88			
359	0.008	1	02/25/88			
360	<0.001	1	02/28/88			
361	<0.001	1	02/26/88			
362	0.004	1	03/01/88			
363	0.002	1	03/02/88			
364	0.001	1	03/05/88			
365	<0.001	1	03/05/88			
366	<0.001	1	03/04/88			
367	<0.001	1	03/07/88			
368	0.001	1	03/06/88			
369	<0.001	1	03/08/88			
370	<0.001	1	03/10/88			
371	<0.001	1	03/13/88			
372	<0.001	1	03/12/88			
373	0.001	1	03/16/88			
374	<0.001	1	03/17/88			
375	<0.001	1	03/20/88			
376	0.001	1	03/18/88			
377	0.003	1	03/22/88			
378	0.011	1	03/23/88			
379	0.002	1	03/24/88			

^aDisposition codes as defined by the facility are as follows: (1) transported to sanitary landfill for disposal; (2) reanalyzed because of suspected contamination; (3) returned to treatment system for reprocessing; and (4) transported to licensed hazardous waste landfill for disposal.

^bThe design values associated with these operating data are presented in Table 4-1.

Table 4-4 Acid Leaching, Chemical Oxidation, and Sludge Dewatering/Acid Washing Data Submitted by Plant B

Sample no.	Treated mercury concentration (ppm)		Operating information ^a				
	Total	EP	Date sampled	Acidification reactor pH	Hypochlorite reactor pH	Hypochlorite reactor residence time (min)	Filter vacuum (in Hg)
1	-	0.0047	1/13/88	3.8	6.8	20-40	9-12
2	-	0.0208	1/13/88	3.8	6.8	20-40	9-12
3	-	0.0054	1/15/88	2.8	6.4	20-40	9-12
4	7.38	0.0030	1/19/88	-	-	20-40	9-12
5	8.68	0.0096	1/20/88	2.2	7.8	20-40	9-12
6	27.54	0.0092	1/20/88	2.3	7.4	20-40	9-12
7	13.45	0.0085	1/21/88	2.2	7.6	20-40	9-12
8	-	0.0175	1/21/88	2.1	7.4	20-40	9-12
9	-	0.0164	2/05/88	2.6	7.6	20-40	9-12
10	-	0.0098	2/11/88	2.8	7.4	20-40	7-9
11	-	0.0140	2/18/88	3.0	6.0	20-40	7-9
12	-	0.0113	4/15/88	2.1	6.9	20-40	7-9
13	-	0.0131	4/15/88	-	-	20-40	7-9
14	-	0.0710	4/21/88	2.0	6.8	20-40	7-9
15	-	0.0480	4/21/88	2.0	6.9	20-40	7-9
16	-	0.0090	4/22/88	2.0	7.2	20-40	7-9
17	-	0.0220	4/22/88	-	6.8	20-40	7-9
18	-	0.0661	5/02/88	2.5	7.1	20-40	7-9
19	-	0.0087	5/03/88	2.9	7.2	20-40	7-9

^aThe design values associated with these data are assumed to be similar to the design values presented in Table 4-1.

Reference: B.F. Goodrich 1988 (LDRU-L0011).

Table 4-5 Sludge Dewatering/Water Washing Data Submitted by Plant C^a

Constituent	Measurement	Treated waste concentration (nonwastewater)					
		Sample set					
		#1	#2	#3	#4	#5	#6
Arsenic	Total (mg/kg)	3.7	4.3	0.82	0.49	1.1	1.4
	EP (mg/l)	<0.005 (<0.005)	<0.005	<0.005	<0.005	<0.005	<0.005
Barium	Total (mg/kg)	34	37	6.3	3.9	16	15
	EP (mg/l)	0.4 (<0.005)	0.33	<0.30	0.30	<0.30	<0.30
Cadmium	Total (mg/kg)	1.4	1.3	1.1	3.4	3.0	2.0
	EP (mg/l)	0.016 (0.01)	0.009	0.008	0.009	0.009	<0.006
Chromium	Total (mg/kg)	13	16	3.9	4.3	15	26
	EP (mg/l)	<0.005 (<0.005)	<0.005	<0.005	<0.005	<0.005	0.11
Lead	Total (mg/kg)	42	48	10	4.9	25	32
	EP (mg/l)	0.08 (0.09)	0.06	0.06	<0.03	0.31	0.07
Mercury	Total (mg/kg)	150	120	78	60	82	95
	EP (mg/l)	0.013 (0.014)	0.014	0.018	0.013	0.024	0.021
Nickel	Total (mg/kg)	11	12	2.0	2.0	8.4	12
	EP (mg/l)	0.06	0.05	0.06	0.02	0.08	0.06
Selenium	Total (mg/kg)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
	EP (mg/l)	<0.005 (<0.005)	<0.005	<0.005	<0.005	<0.005	<0.005
Silver	Total (mg/kg)	0.51	0.58	0.89	<0.5	<0.5	<0.5
	EP (mg/l)	<0.005 (<0.005)	<0.005	<0.005	<0.005	<0.005	<0.005

^aDesign and operating data are not available.

Table 4-5 (Continued)

Constituent	Measurement	Treated waste concentration (nonwastewater)					
		Sample set					
		#7	#8	#9	#10	#11	#12
Arsenic	Total (mg/kg)	7.7	7.5	25	6.8	53	5.0
	EP (mg/l)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005 (<0.005)
Barium	Total (mg/kg)	200	67	71	110	57	120
	EP (mg/l)	0.52	<0.30	<0.30	<0.30	<0.30	<0.30 (0.40)
Cadmium	Total (mg/kg)	5.2	3.5	3.9	1.3	<0.50	0.53
	EP (mg/l)	0.012	0.012	0.009	<0.006	<0.006	0.014 (0.017)
Chromium	Total (mg/kg)	700	430	390	760	540	820
	EP (mg/l)	0.010	0.019	<0.005	0.018	0.011	<0.005 (<0.005)
Lead	Total (mg/kg)	38	42	62	110	41	30
	EP (mg/l)	0.09	0.08	0.11	0.08	0.10	0.10 (0.06)
Mercury	Total (mg/kg)	240	92	78	72	53	150
	EP (mg/l)	0.011	0.003	<0.0005	0.0082	0.0007	<0.0005 (<0.0005)
Nickel	Total (mg/kg)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
	EP (mg/l)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Selenium	Total (mg/kg)	4.7	0.80	<0.5	<0.5	<0.5	<0.5
	EP (mg/l)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005 (<0.005)
Silver	Total (mg/kg)	100	44	56	260	50	48
	EP (mg/l)	0.40	0.12	1.2	0.44	0.10	0.23 (0.80)

^aDesign and operating data are not available.

Note: Numbers in parentheses under sample sets #1 and #6 are TCLP leachate concentrations.

Reference: Occidental Chemical Corporation 1987a.

Table 4-6 Sludge Dewatering/Water Washing Data Submitted by Plant D^a

Constituent	Measurement	Treated waste concentration (nonwastewater)					
		Sample set					
		#1	#2	#3	#4	#5	#6
Arsenic	Total (mg/kg)	0.46	0.73	<0.52	0.70	0.63	0.54
	EP (mg/l)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Barium	Total (mg/kg)	35	45	86	81	15	97
	EP (mg/l)	0.11	0.19	0.24	<0.20	0.05	0.02
Cadmium	Total (mg/kg)	0.02	<0.73	<0.73	0.71	<0.63	<0.76
	EP (mg/l)	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008
Chromium	Total (mg/kg)	7.5	6.7	6.6	6.3	7.0	6.8
	EP (mg/l)	<0.005	<0.005	<0.005	<0.006	<0.005	<0.005
Lead	Total (mg/kg)	82	86	97	89	41	86
	EP (mg/l)	0.10	0.11	0.12	0.14	0.12	0.10
Mercury	Total (mg/kg)	5.7	6.2	6.5	5.9	3.9	3.3
	EP (mg/l)	<0.002	<0.002	<0.005	<0.005	<0.005	<0.005
Nickel	Total (mg/kg)	<0.46	<0.52	<0.52	<0.50	<0.45	<0.54
	EP (mg/l)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Selenium	Total (mg/kg)	<0.46	<0.52	<0.52	<0.50	<0.45	<0.54
	EP (mg/l)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Silver	Total (mg/kg)	14	11	13	12	4.4	11
	EP (mg/l)	0.10	0.12	0.15	0.13	<0.07	0.12

^aDesign and operating data are not available.

Table 4-6 (Continued)

Constituent	Measurement	Treated waste concentration (nonwastewater)					
		Sample set					
		#7	#8	#9	#10	#11	#12
Arsenic	Total (mg/kg)	<0.58	0.61	<0.40	0.96	0.89	1.1
	EP (mg/l)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Barium	Total (mg/kg)	180	82	33	39	29	22
	EP (mg/l)	0.30	0.43	<0.02	<0.02	<0.02	0.11
Cadmium	Total (mg/kg)	<0.81	<0.71	0.78	0.74	1.3	0.84
	EP (mg/l)	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008
Chromium	Total (mg/kg)	7.6	6.8	6.5	6.6	6.7	6.6
	EP (mg/l)	0.006	<0.005	<0.005	<0.005	<0.005	<0.005
Lead	Total (mg/kg)	110	72	96	110	85	94
	EP (mg/l)	0.10	0.10	0.06	0.10	0.11	0.09
Mercury	Total (mg/kg)	4.2	4.9	4.2	3.6	4.0	2.9
	EP (mg/l)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Nickel	Total (mg/kg)	<0.58	<0.51	<0.40	<0.48	<0.80	0.54
	EP (mg/l)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Selenium	Total (mg/kg)	<0.58	<0.51	<0.40	<0.48	<0.80	0.54
	EP (mg/l)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Silver	Total (mg/kg)	13	7.1	19	21	15	16
	EP (mg/l)	0.17	0.09	0.19	0.28	0.12	0.19

Table 4-6 (Continued)

Constituent	Measurement	Treated waste concentration (nonwastewater)					
		Sample set					
		#13	#14	#15	#16	#17	#18
Arsenic	Total (mg/kg)	6.0	7.7	15	<0.51	2.5	7.3
	EP (mg/l)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Barium	Total (mg/kg)	70	56	60	24	7.9	42
	EP (mg/l)	0.05	0.11	0.27	0.21	0.11	<0.04
Cadmium	Total (mg/kg)	<0.63	<0.71	<0.78	<0.71	<0.69	<0.77
	EP (mg/l)	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008
Chromium	Total (mg/kg)	17	16	17	11	5.7	16
	EP (mg/l)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Lead	Total (mg/kg)	330	340	340	170	100	200
	EP (mg/l)	0.35	0.77	0.40	0.08	0.11	0.10
Mercury	Total (mg/kg)	3.5	3.7	4.8	2.3	6.9	11
	EP (mg/l)	0.0080	0.0063	<0.032	0.0080	<0.002	0.0093
Nickel	Total (mg/kg)	<0.47	<0.51	<0.56	<0.51	<0.49	<0.95
	EP (mg/l)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Selenium	Total (mg/kg)	<0.47	<0.51	<0.56	<1.6	<0.49	<0.95
	EP (mg/l)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Silver	Total (mg/kg)	92	76	81	69	30	95
	EP (mg/l)	0.66	0.63	0.79	0.22	0.14	0.16

Table 4-6 (Continued)

Constituent	Measurement	Treated waste concentration (nonwastewater)					
		Sample set					
		#19	#20	#21	#22	#23	#24
Arsenic	Total (mg/kg)	6.1	7.9	<0.6	<0.6	<0.6	<0.6
	EP (mg/l)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Barium	Total (mg/kg)	98	79	<3.0	<3.0	<3.0	50
	EP (mg/l)	<0.02	0.38	<0.03	<0.03	<0.03	0.06
Cadmium	Total (mg/kg)	<0.70	<0.70	0.73	<0.70	0.73	0.50
	EP (mg/l)	<0.008	<0.008	<0.005	0.005	<0.005	<0.005
Chromium	Total (mg/kg)	19	20	0.10	0.78	0.62	0.10
	EP (mg/l)	<0.005	<0.005	0.007	<0.005	0.007	0.006
Lead	Total (mg/kg)	310	430	79	42	34	42
	EP (mg/l)	0.36	0.33	0.15	0.17	0.11	0.12
Mercury	Total (mg/kg)	2.0	9.6	5.5	1.8	3.0	3.4
	EP (mg/l)	0.013	0.014	0.0008	<0.0005	<0.0005	<0.0005
Nickel	Total (mg/kg)	<0.50	<0.52	<3	<3	6.2	3.0
	EP (mg/l)	<0.005	<0.005	<0.03	<0.04	0.03	<0.03
Selenium	Total (mg/kg)	<0.50	<0.52	<0.6	<0.6	<0.6	<0.6
	EP (mg/l)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Silver	Total (mg/kg)	77	220	1.3	<0.6	0.83	<0.6
	EP (mg/l)	0.46	1.22	<0.005	<0.005	<0.005	<0.005

^aDesign and operating data are not available.

Reference: Occidental Chemical Corporation 1987b.

1558g

Table 4-7 Sludge Dewatering/Water Washing Data Submitted by Plant E^a

Sample no.	Treated mercury concentration EP (mg/l)	Sampling quarter
1	0.013	3rd '87
2	0.005	
3	0.017	
4	0.020	
5	0.048	
6	0.070	
7	0.002	
8	0.008	
9	0.013	
10	0.010	2nd '87
11	0.009	
12	0.004	
13	<0.002	
14	0.008	
15	0.004	
16	0.003	
17	0.012	
18	0.007	
19	0.011	
20	0.006	
21	0.001	
22	0.009	
23	0.002	
24	0.001	
25	0.003	
26	0.004	
27	<0.001	
28	0.009	
29	0.003	
30	0.015	
31	0.006	
32	0.009	
33	0.008	
34	0.005	
35	0.011	
36	0.014	
37	0.010	
38	0.002	
39	0.005	
40	0.012	
41	0.002	

^aDesign and operating data are not available.

1558g

Table 4-7 (Continued)

Sample no.	Treated mercury concentration EP (mg/l)	Sampling quarter
42	0.010	
43	<0.001	
44	0.010	
45	<0.001	
46	0.001	
47	<0.001	
48	0.002	
49	0.004	
50	0.003	
51	0.022	
52	0.006	
53	0.005	
54	0.015	1st '87
55	0.030	
56	0.013	
57	0.018	
58	0.024	
59	0.010	
60	<0.001	
61	0.012	
62	0.017	
63	0.009	
64	0.006	
65	0.001	
66	0.001	
67	0.011	
68	0.012	
69	0.007	
70	0.006	
71	0.016	
72	0.040	
73	0.010	
74	0.016	
75	0.024	
76	0.021	
77	0.010	
78	0.013	
79	<0.001	
80	0.014	
81	0.012	

Table 4-7 (Continued)

Sample no.	Treated mercury concentration EP (mg/l)	Sampling quarter
82	0.027	
83	0.020	
84	0.010	
85	0.023	
86	0.046	
87	0.005	
88	0.025	
89	0.036	
90	0.024	
91	0.009	4th '86
92	0.012	
93	0.030	
94	0.039	
95	0.036	
96	0.033	
97	0.049	
98	0.035	
99	0.037	
100	0.030	
101	0.009	
102	0.006	
103	0.009	
104	0.006	
105	0.016	
106	0.009	
107	0.014	
108	0.010	
109	0.008	
110	0.007	
111	0.006	
112	0.006	
113	<0.001	
114	0.003	
115	0.009	
116	0.021	
117	0.006	
118	0.027	
119	0.035	
120	0.028	
121	0.029	
122	0.034	3rd '86

Table 4-7 (Continued)

Sample no.	Treated mercury concentration EP (mg/l)	Sampling quarter
123	<0.001	
124	0.013	
125	0.007	
126	0.014	
127	0.056	
128	0.037	
129	0.026	
130	0.016	
131	0.023	
132	0.037	
133	0.037	
134	0.039	
135	0.001	
136	0.039	
137	0.002	
138	0.041	
139	0.072	
140	0.005	
141	0.107	
142	0.036	
143	0.008	
144	0.039	
145	0.014	2nd '86
146	0.005	
147	0.034	
148	0.004	
149	0.002	
150	0.004	
151	0.008	
152	0.066	
153	0.001	
154	0.004	
155	<0.001	
156	0.002	
157	0.007	
158	0.005	
159	0.018	
160	0.022	
161	0.031	
162	0.014	
163	0.091	

Table 4-7 (Continued)

Sample no.	Treated mercury concentration EP (mg/l)	Sampling quarter
164	0.037	
165	0.164	
166	0.005	
167	0.008	
168	0.004	1st '86
169	0.005	
170	0.091	
171	0.011	
172	0.038	
173	0.090	
174	0.065	
175	0.007	
176	0.012	
177	0.020	
178	0.016	
179	0.030	
180	0.114	
181	0.169	
182	0.051	
183	0.012	
184	0.045	
185	0.037	
186	0.027	
187	0.029	
188	0.055	
189	0.115	
190	0.041	
191	0.030	
192	0.033	
193	0.025	
194	0.022	4th '85
195	0.040	
196	0.001	
197	0.038	
198	0.016	
199	0.020	
200	0.021	
201	0.038	
202	0.039	
203	0.027	
204	0.023	

Table 4-7 (Continued)

Sample no.	Treated mercury concentration EP (mg/l)	Sampling quarter
205	0.015	
206	0.026	
207	0.023	
208	0.029	
209	0.010	
210	0.023	
211	0.023	
212	0.027	
213	0.032	
214	0.028	
215	0.035	
216	0.027	
217	0.031	
218	0.064	
219	0.031	
220	0.022	
221	0.025	
222	0.035	
223	0.050	
224	0.031	
225	0.026	
226	0.042	
227	0.063	
228	0.044	
229	0.043	
230	0.053	
231	0.022	
232	0.017	

^aDesign and operating data are not available.

Reference: Bennett 1986.

Table 4-8 Chemical Precipitation and Filtration Data Collected
by EPA at Plant A

Sample Set #1

Constituent	Untreated wastewater (mg/l)	Filter cake (K106) ^a		Treated wastewater (mg/l)
		Total (mg/kg)	TCLP (mg/l)	
Arsenic	<0.2	1.1	<0.01	<0.2
Barium	0.248	74	0.74	0.103
Cadmium	<0.03	2.3	0.02	<0.06
Chromium	<0.06	6.3	<0.01	0.553
Copper	0.097	133	<0.02	<0.16
Lead	<0.66	50	0.13	<1.32
Mercury	23.7	25,900	0.01	0.028
Nickel	0.157	14	0.15	0.275
Silver	0.148	131	<0.02	<0.1
Vanadium	<0.04	0.46	<0.01	<0.08
Zinc	0.615	443	1.7	0.047

Note: Design and operating parameters are as follows:

Parameter	Design value	Operating value
Excess sulfide	>40 mg/l	85 mg/l

^aOnly one sample was collected of the filter cake (K106).

Reference: USEPA 1988a. Tables 3-2 and 5-9.

Table 4-8 (Continued)

Sample Set #2

Constituent	Untreated wastewater (mg/l)	Filter cake (K106) ^a		Treated wastewater (mg/l)
		Total (mg/kg)	TCLP (mg/l)	
Arsenic	<0.1	1.1	<0.01	<0.1
Barium	0.226	74	0.74	0.158
Cadmium	<0.06	2.3	0.02	<0.06
Chromium	0.189	6.3	<0.01	<0.12
Copper	<0.16	133	<0.02	<0.16
Lead	<1.32	50	0.13	<1.32
Mercury	9.25	25,900	0.01	0.027
Nickel	<0.26	14	0.15	<0.26
Silver	0.1	131	<0.02	<0.1
Vanadium	<0.08	0.46	<0.01	<0.08
Zinc	0.88	443	1.7	<0.04

Note: Design and operating parameters are as follows:

Parameter	Design value	Operating value
Excess sulfide	>40 mg/l	101 mg/l

^aOnly one sample was collected of the filter cake (K106).

Reference: USEPA 1988a. Tables 3-2 and 5-10.

Table 4-8 (Continued)

Sample Set #3

Constituent	Untreated wastewater (mg/l)	Filter cake (K106) ^a		Treated wastewater (mg/l)
		Total (mg/kg)	TCLP (mg/l)	
Arsenic	<0.1	1.1	<0.01	<0.1
Barium	0.293	74	0.74	0.144
Cadmium	<0.06	2.3	0.02	<0.06
Chromium	<0.12	6.3	<0.01	<0.12
Copper	<0.16	133	<0.02	<0.16
Lead	<1.32	50	0.13	<1.32
Mercury	77.2	25,900	0.01	0.028
Nickel	<0.26	14	0.15	<0.26
Silver	0.12	131	<0.02	<0.1
Vanadium	<0.08	0.46	<0.01	<0.08
Zinc	0.535	443	1.7	0.064

Note: Design and operating parameters are as follows:

Parameter	Design value	Operating value
Excess sulfide	>40 mg/l	96 mg/l

^aOnly one sample was collected of the filter cake (K106).

Reference: USEPA 1988a. Tables 3-2 and 5-11.

5. IDENTIFICATION OF BEST DEMONSTRATED AVAILABLE TECHNOLOGY (BDAT)

This section explains EPA's determination of the best demonstrated available technology (BDAT) for K071 waste. As discussed in Section 1, the BDAT for a waste must be the "best" of the "demonstrated" technologies; the BDAT must also be "available." In general, the technology that constitutes "best" is determined after screening the available performance data from each technology, adjusting these data for accuracy, and comparing the performance of each technology to that of the others. If only one technology is identified as demonstrated, this technology is considered "best." To be "available," a technology (1) must be commercially available and (2) must provide substantial treatment.

5.1 Nonwastewater

The Agency has performance data showing treatment of K071 nonwastewater from two technologies: (1) acid leaching followed by chemical oxidation and then sludge dewatering/acid washing, and (2) sludge dewatering/water washing.

Data from the first technology include the EPA-collected data at Plant A, Plant A.1 data (see Table 4-1); the data submitted by Plant A, Plant A.2 data (see Table 4-3); and the data submitted by Plant B (see Table 4-4). For the second technology, data are available from Plants C (see Table 4-5), D (see Table 4-6), and E (see Table 4-7).

In screening these data, EPA examined the associated design and operating data, quality assurance/quality control (QA/QC) information, and the measure of performance (e.g., total constituent concentration or TCLP leachate concentration).

Design and operating information that accompanies the Plant A.1, Plant B, and 56 of the 379 data points from the Plant A.2 data show that these data reflect well-designed and well-operated systems. Design and operating data are not available for the remainder of the Plant A.2 data or for data from Plants C, D, and E.

The concentrations of mercury in analyzed samples from Plants A.2, B, and E data are assumed to have been adjusted prior to being submitted to the Agency. As discussed later in Section 6, mercury is the only selected regulated constituent in K071 waste. Recoveries for mercury in the QA/QC information, used for adjusting the mercury data for accuracy, are available for Plants A, C, and D. This information is presented in Appendix B.

The measure of performance for mercury in K071 nonwastewater is its concentration in the leachate from the TCLP. TCLP data are available only for the data collected by EPA at Plant A and for data submitted by Plant C (2 of 12 mercury results are reported as TCLP leachate concentrations from the latter plant). The remaining data are reported as total or EP leachate concentrations. Normally, the EP leachate data would not be considered in the development of a treatment standard to be regulated as a TCLP concentration. However, industry-submitted data

indicate that for mercury in K071 nonwastewater there is no statistical difference between the values obtained from the two types of measurement (see Appendix C).

During the screening of all 673 TCLP and EP nonwastewater data points for mercury, the Agency eliminated 34--1 from Table 4-1 and 33 from Table 4-3. The Table 4-1 data point from Plant A (Sample Set #3) was discarded because the leachate concentration was higher than the corresponding total waste concentration, an indication of error in either sampling or analysis. Of the 33 discarded data points from Table 4-3, the 31 data points marked with disposition codes 2 and 3 were not considered further because of suspected sample contamination or because the waste was returned to the treatment system for reprocessing, an indication of poor operation. The other two data points from Table 4-3 were discarded because the Agency determined they were representative of poor operation. (Operating information was not actually available for the last two eliminated data points. EPA's determination of poor operation was based on the fact that the concentrations of mercury in the EP leachates were greater than the highest mercury concentration observed (0.070 mg/l) in the acid leaching, oxidation, sludge dewatering/acid washing data that meet the well-designed and well-operated criteria.)

In cases where data showing treatment are available for more than one technology, the Agency performs an analysis of variance (ANOVA) test (see Appendix A) to determine which technology performs significantly better than the others. The usable performance data must be corrected for accuracy before performing the ANOVA test. Basically, the adjustment

involves multiplying the treatment value by an accuracy-correction factor, the reciprocal of the percent recovery. The procedure for selecting the appropriate percent recovery is discussed in detail in Section 1.2. Tables 5-1 and 5-2 present the accuracy-corrected mercury data. Percent recoveries are presented in Appendix B.

For K071 waste, an ANOVA test was performed on the treated TCLP and EP mercury data from treatment by acid leaching followed by chemical oxidation and then dewatering/acid washing (6 data points from the Plant A.1 data, 346 from the Plant A.2 data, and 19 from the Plant B data) and from treatment by dewatering/water washing (12 data points from Plant C, 24 from Plant D, and 232 from Plant E). Results of the ANOVA test are presented in Table 5-3. Results indicate that the "best" demonstrated technology is acid leaching followed by chemical oxidation and sludge dewatering/acid washing.

Treatment by acid leaching followed by chemical oxidation and then sludge dewatering/acid washing is considered "available" because (1) all three processes in the system are commercially available and (2) the treatment substantially diminishes the toxicity of the waste and substantially reduces the likelihood that hazardous constituents will migrate from the waste. For example, as shown by the Plant A.1 data, the TCLP leachate mercury concentrations ranging from 0.44 to 20 ppm fell to less than 0.0017 ppm (corrected for accuracy). (For the Plant A.2 and B data, untreated waste concentrations were not available.)

Having shown the technology to be "best," "demonstrated," and "available" for K071 nonwastewater, EPA considers acid leaching followed by chemical oxidation and then sludge dewatering/acid washing to be BDAT.

5.2 Wastewater

For metals in K071 wastewater, the demonstrated treatment technology is chemical precipitation followed by filtration. Performance data are available for chemical precipitation, using sulfide as the treatment chemical, and filtration, as discussed in Sections 3 and 4. The performance data meet the screening criteria outlined in Section 1.2. The Agency does not expect that the use of other treatment chemicals would improve the level of performance. Thus, chemical precipitation, using sulfide, followed by filtration is "best."

Chemical precipitation, using sulfide, followed by filtration is "available" because such treatment is commercially available and provides substantial treatment for K071 wastewater. EPA's determination of substantial treatment is based on the fact that the concentrations of mercury were reduced to less than 0.030 mg/l (corrected for accuracy) from 9.25 to 77.2 mg/l in the untreated wastewater. The accuracy-corrected data are presented in Table 5-4.

As chemical precipitation followed by filtration is "best," "demonstrated," and "available" for K071 wastewater, the treatment is BDAT.

Table 5-1 Accuracy-Corrected Mercury Data for Acid Leaching, Chemical Oxidation,
and Sludge Dewatering/Acid Washing

Data source	Sample no.	Treated TCLP or EP concentration (mg/l)	Accuracy-correction factor	Accuracy-corrected data (mg/l)
Plant A.1	1	0.0003	1/0.95	0.0003
	2	<0.0002	1/0.95	<0.0002
	3 ^a	2.0	-	-
	4	0.0002	1/0.95	0.0002
	5	0.0005	1/0.95	0.0005
	6	0.0016	1/0.95	0.0017
	7	<0.0002	1/0.95	<0.0002
Plant A.2 ^b	1 ^c			0.018
	2 ^c			0.056
	3			0.008
	4 ^c			0.025
	5			<0.002
	6			<0.002
	7			0.007
	8			0.002
	9			<0.002
	10			0.012
	11			0.003
	12			0.004
	13			0.002
	14			<0.002
	15			<0.002
	16			<0.002
	17			0.001
	18			0.003
	19			<0.001
	20			<0.002
	21			<0.002
	22			<0.002
	23			<0.002
	24			<0.002
	25			<0.001
	26			<0.001
	27			<0.002
	28			<0.002
	29			<0.002
	30			<0.001
	31			0.002

^aData point was eliminated because of suspected sampling or analytical error.

^bData were not accompanied by recovery information for mercury; data are assumed to be corrected for accuracy.

^cData points were eliminated under disposition code 2 or 3 (see text).

Table 5-1 (Continued)

Data source	Sample no.	Treated TCLP or EP concentration (mg/l)	Accuracy-correction factor	Accuracy-corrected data (mg/l)
Plant A.2 ^b	32			<0.001
	33			<0.001
	34			<0.001
	35			<0.001
	36			<0.001
	37			0.001
	38			0.002
	39			0.001
	40			0.002
	41			0.001
	42			0.009
	43			<0.001
	44			0.012
	45			0.001
	46			<0.001
	47 ^c			0.015
	48 ^c			0.016
	49 ^c			0.027
	50 ^c			0.028
	51 ^c			0.026
	52			<0.001
	53			<0.001
	54			<0.001
	55			0.001
	56			<0.001
	57			<0.001
	58			<0.001
	59			<0.001
	60			<0.001
	61			<0.001
	62			<0.001
	63			0.001
	64			<0.001
	65			<0.001
	66			<0.001
	67			<0.001
	68			<0.001
	69			<0.001
	70			<0.001
	71			<0.001

^bData were not accompanied by recovery information for mercury; data are assumed to be corrected for accuracy.

^cData points were eliminated under disposition code 2 or 3 (see text).

Table 5-1 (Continued)

Data source	Sample no.	Treated TCLP or EP concentration (mg/l)	Accuracy-correction factor	Accuracy-corrected data (mg/l)
Plant A.2 ^b	72			<0.001
	73			<0.001
	74			0.001
	75			0.004
	76			<0.001
	77			0.001
	78			0.001
	79			0.004
	80			<0.001
	81			<0.001
	82			<0.001
	83 ^c			0.018
	84 ^c			0.018
	85			0.008
	86			<0.001
	87			0.001
	88			0.001
	89			0.007
	90 ^c			0.017
	91			<0.001
	92			0.006
	93			0.005
	94			0.009
	95			0.001
	96			0.002
	97			<0.001
	98			0.002
	99			0.002
	100			0.004
	101			0.002
	102			0.002
	103			0.001
	104			0.001
	105			0.001
	106			0.005
	107			0.005
	108			0.003
	109			0.003
	110			0.002
	111			<0.001

^bData were not accompanied by recovery information for mercury; data are assumed to be corrected for accuracy.

^cData points were eliminated under disposition code 2 or 3 (see text).

Table 5-1 (Continued)

Data source	Sample no.	Treated TCLP or EP concentration (mg/l)	Accuracy-correction factor	Accuracy-corrected data (mg/l)
Plant A.2 ^b	112			<0.001
	113			<0.001
	114			<0.001
	115			0.001
	116			<0.001
	117			<0.001
	118			<0.001
	119			<0.001
	120			0.001
	121 ^c			0.017
	122			<0.001
	123			0.003
	124			0.006
	125			<0.001
	126			0.002
	127			<0.001
	128			<0.001
	129			0.002
	130			<0.001
	131			<0.001
	132			<0.001
	133			0.001
	134			<0.001
	135			0.001
	136			<0.001
	137			<0.001
	138			<0.001
	139			<0.001
	140			0.003
	141			0.003
	142			0.001
	143			0.006
	144			0.003
	145			<0.001
	146			0.001
	147			<0.001
	148			0.012
	149			<0.001
	150			<0.002
	151			0.003

^bData were not accompanied by recovery information for mercury; data are assumed to be corrected for accuracy.

^cData points were eliminated under disposition code 2 or 3 (see text).

Table 5-1 (Continued)

Data source	Sample no.	Treated TCLP or EP concentration (mg/l)	Accuracy-correction factor	Accuracy-corrected data (mg/l)
Plant A.2 ^b	152 ^c			0.018
	153 ^c			0.060
	154 ^c			0.031
	155			0.002
	156			<0.001
	157			<0.001
	158			<0.001
	159			<0.001
	160			0.001
	161 ^c			0.060
	162 ^c			0.031
	163 ^c			0.021
	164			0.011
	165			<0.001
	166			<0.001
	167 ^c			0.016
	168			0.008
	169			0.007
	170			<0.001
	171			<0.001
	172 ^c			0.013
	173 ^c			0.032
	174 ^c			0.017
	175			0.006
	176			0.007
	177			0.001
	178			<0.001
	179 ^c			0.021
	180			0.004
	181			0.008
	182			0.005
	183			0.003
	184			0.001
	185			0.005
	186			0.007
	187			0.002
	188 ^c			0.040
	189			0.010
	190			0.001
	191			0.008

^bData were not accompanied by recovery information for mercury; data are assumed to be corrected for accuracy.

^cData points were eliminated under disposition code 2 or 3 (see text).

Table 5-1 (Continued)

Data source	Sample no.	Treated TCLP or EP concentration (mg/l)	Accuracy-correction factor	Accuracy-corrected data (mg/l)
Plant A.2 ^b	192			0.005
	193			0.012
	194			0.002
	195			0.002
	196 ^c			0.028
	197			0.040
	198 ^c			0.022
	199			0.011
	200 ^d			0.240
	201			0.032
	202			0.031
	203			0.014
	204			0.003
	205			0.003
	206			0.012
	207			0.008
	208			0.002
	209			0.007
	210			0.005
	211			0.003
	212			0.012
	213			0.004
	214			0.004
	215			<0.001
	216			0.010
	217			<0.001
	218			0.002
	219 ^d			0.150
	220			0.010
	221			0.010
	222			0.005
	223			0.002
	224			0.002
	225			0.002
	226			0.005
	227 ^c			0.014
	228			0.001
	229			0.003
	230			0.068
	231			0.003

^bData were not accompanied by recovery information for mercury; data are assumed to be corrected for accuracy.

^cData points were eliminated under disposition code 2 or 3 (see text).

^dData points were eliminated because of poor operation determination (see text).

Table 5-1 (Continued)

Data source	Sample no.	Treated TCLP or EP concentration (mg/l)	Accuracy-correction factor	Accuracy-corrected data (mg/l)
Plant A.2 ^b	232			<0.001
	233			0.009
	234			0.009
	235			0.005
	236			0.005
	237			0.003
	238			0.002
	239			0.008
	240			0.002
	241			0.008
	242			0.032
	243			0.012
	244			0.011
	245			0.003
	246			0.006
	247			0.028
	248			0.003
	249			0.001
	250			0.006
	251			<0.001
	252			<0.001
	253			<0.001
	254			0.001
	255			0.003
	256			0.006
	257			0.002
	258			0.001
	259			0.010
	260			0.006
	261			0.005
	262			0.011
	263			0.007
	264			0.011
	265			0.002
	266 ^c			0.012
	267			0.004
	268			0.021
	269			0.005
	270			0.003
	271 ^c			0.026

^bData were not accompanied by recovery information for mercury; data are assumed to be corrected for accuracy.

^cData points were eliminated under disposition code 2 or 3 (see text).

Table 5-1 (Continued)

Data source	Sample no.	Treated TCLP or EP concentration (mg/l)	Accuracy-correction factor	Accuracy-corrected data (mg/l)
Plant A.2 ^b	272			0.009
	273			0.004
	274			0.004
	275 ^c			0.016
	276			0.008
	277			0.002
	278			0.001
	279			<0.001
	280			<0.001
	281			<0.001
	282			0.001
	283			0.006
	284			0.004
	285			0.010
	286			0.002
	287			0.003
	288			0.004
	289			<0.001
	290			<0.001
	291			<0.001
	292			0.001
	293			<0.001
	294			<0.001
	295			<0.001
	296			<0.001
	297			<0.001
	298			<0.001
	299			<0.001
	300			0.008
	301			<0.001
	302			0.001
	303			0.008
	304			0.001
	305			0.001
	306			0.003
	307			<0.001
	308			0.002
	309			<0.001
	310			<0.001
	311			<0.001
	313			0.002
	314			0.008

^bData were not accompanied by recovery information for mercury; data are assumed to be corrected for accuracy.

^cData points were eliminated under disposition code 2 or 3 (see text).

Table 5-1 (Continued)

Data source	Sample no.	Treated TCLP or EP concentration (mg/l)	Accuracy-correction factor	Accuracy-corrected data (mg/l)
Plant A.2 ^b	315			0.003
	316			0.005
	317			<0.001
	318			<0.001
	319			<0.001
	320			<0.001
	321			0.004
	322			0.001
	323			0.002
	324			0.001
	325			<0.001
	326			<0.001
	327			0.001
	328			0.002
	329			<0.001
	330			0.002
	331			<0.001
	332			0.004
	333			0.004
	334			<0.001
	335 ^c			0.500
	336			0.001
	337			0.001
	338			<0.001
	339			<0.001
	340			<0.001
	341			<0.001
	342			<0.001
	343			0.001
	344			0.001
	345			0.001
	346			0.001
	347			<0.001
	348			0.001
	349			0.001
	350			<0.001
	351			0.003
	352			<0.001
	353			<0.001

^bData were not accompanied by recovery information for mercury; data are assumed to be corrected for accuracy.

^cData points were eliminated under disposition code 2 or 3 (see text).

Table 5-1 (Continued)

Data source	Sample no.	Treated TCLP or EP concentration (mg/l)	Accuracy-correction factor	Accuracy-corrected data (mg/l)
Plant A.2 ^b	354			0.004
	355			0.008
	356			0.001
	357			0.001
	358			<0.001
	359			0.008
	360			<0.001
	361			<0.001
	362			0.004
	363			0.002
	364			0.001
	365			<0.001
	366			<0.001
	367			<0.001
	368			0.001
	369			<0.001
	370			<0.001
	371			<0.001
	372			<0.001
	373			0.001
	374			<0.001
	375			<0.001
	376			0.001
	377			0.003
	378			0.011
	379			0.002
Plant B ^b	1			0.0047
	2			0.0208
	3			0.0054
	4			0.0030
	5			0.0096
	6			0.0092
	7			0.0085
	8			0.0175
	9			0.0164
	10			0.0098
	11			0.0140
	12			0.0113
	13			0.0131

^bData were not accompanied by recovery information for mercury; data are assumed to be corrected for accuracy.

Table 5-1 (Continued)

Data source	Sample no.	Treated TCLP or EP concentration (mg/l)	Accuracy-correction factor	Accuracy-corrected data (mg/l)
Plant B ^b	14			0.0710
	15			0.0480
	16			0.0090
	17			0.0220
	18			0.0661
	19			0.0087

^aData point eliminated because of suspected sampling or analytical error.

^bData were not accompanied by recovery information for mercury; data are assumed to be corrected for accuracy.

^cData points were eliminated under disposition code 2 or 3 (see text).

^dData points were eliminated because of poor operation determination (see text).

Table 5-2 Accuracy-Corrected Mercury Data for Sludge Dewatering/Water Washing

Data source	Sample no.	Treated TCLP or EP concentration (mg/l)	Accuracy-correction factor	Accuracy-corrected data (mg/l)
Plant C	1	0.013	1/1.12	0.012
	2	0.014	1/1.17	0.020
	3	0.018	1/1.04	0.017
	4	0.013	1/1.12	0.012
	5	0.024	1/0.81	0.030
	6	0.021	1/0.79	0.027
	7	0.011	1/0.76	0.014
	8	0.003	1/1.05	0.003
	9	<0.0005	1/1.19	<0.0004
	10	0.0082	1/0.80	0.0103
	11	<0.0007	1/0.98	<0.0007
	12	<0.0005	1/0.99	<0.0005
Plant D	1	<0.002	1/0.93	<0.002
	2	<0.002	1/0.93	<0.002
	3	<0.005	1/0.96	<0.005
	4	<0.005	1/0.98	<0.005
	5	<0.005	1/1.04	<0.005
	6	<0.005	1/1.01	<0.005
	7	<0.005	1/1.03	<0.005
	8	<0.005	1/1.01	<0.005
	9	<0.005	1/1.02	<0.005
	10	<0.005	1/1.03	<0.005
	11	<0.005	1/1.01	<0.005
	12	<0.005	1/1.02	<0.005
	13	0.008	1/0.93	0.009
	14	0.0063	1/0.94	0.007
	15	0.032	1/0.82	0.039
	16	0.0080	1/0.87	0.009
	17	<0.002	1/0.92	<0.002
	18	0.0093	1/0.82	0.011
	19	0.013	1/0.80	0.016
	20	0.014	1/0.83	0.017
	21	0.0008	1/1.07	<0.0007
	22	<0.0005	1/1.02	<0.0005
	23	<0.0005	1/1.02	<0.0005
	24	<0.0005	1/1.04	<0.0005

Table 5-2 (Continued)

Data source	Sample no.	Treated TCLP or EP concentration (mg/l)	Accuracy-correction factor	Accuracy-corrected values (mg/l)
Plant E ^a	1			0.013
	2			0.005
	3			0.017
	4			0.020
	5			0.048
	6			0.070
	7			0.002
	8			0.008
	9			0.013
	10			0.010
	11			0.009
	12			0.004
	13			<0.002
	14			0.008
	15			0.004
	16			0.003
	17			0.012
	18			0.007
	19			0.011
	20			0.006
	21			0.001
	22			0.009
	23			0.002
	24			0.001
	25			0.003
	26			0.004
	27			<0.001
	28			0.009
	29			0.003
	30			0.015
	31			0.006
	32			0.009
	33			0.008
	34			0.005
	35			0.011
	36			0.014
	37			0.010
	38			0.002
	39			0.005
	40			0.012
	41			0.002

^aData were not accompanied by recovery information for mercury; data are assumed to be corrected for accuracy.

Table 5-2 (Continued)

Data source	Sample no.	Treated TCLP or EP concentration (mg/l)	Accuracy-correction factor	Accuracy-corrected values (mg/l)
Plant E ^a	42			0.010
	43			<0.001
	44			0.010
	45			<0.001
	46			0.001
	47			<0.001
	48			0.002
	49			0.004
	50			0.003
	51			0.022
	52			0.006
	53			0.005
	54			0.015
	55			0.030
	56			0.013
	57			0.018
	58			0.024
	59			0.010
	60			<0.001
	61			0.012
	62			0.017
	63			0.009
	64			0.006
	65			0.001
	66			0.001
	67			0.011
	68			0.012
	69			0.007
	70			0.006
	71			0.016
	72			0.040
	73			0.010
	74			0.016
	75			0.024
	76			0.021
	77			0.010
	78			0.013
	79			<0.001
	80			0.014
	81			0.012

^aData were not accompanied by recovery information for mercury; data are assumed to be corrected for accuracy.

Table 5-2 (Continued)

Data source	Sample no.	Treated TCLP or EP concentration (mg/l)	Accuracy-correction factor	Accuracy-corrected values (mg/l)
Plant E ^a	82			0.027
	83			0.020
	84			0.010
	85			0.023
	86			0.046
	87			0.005
	88			0.025
	89			0.036
	90			0.024
	91			0.009
	92			0.012
	93			0.030
	94			0.039
	95			0.036
	96			0.033
	97			0.049
	98			0.035
	99			0.037
	100			0.030
	101			0.009
	102			0.006
	103			0.009
	104			0.006
	105			0.016
	106			0.009
	107			0.014
	108			0.010
	109			0.008
	110			0.007
	111			0.006
	112			0.006
	113			<0.001
	114			0.003
	115			0.009
	116			0.021
	117			0.006
	118			0.027
	119			0.035
	120			0.028
	121			0.029
	122			0.034

^aData were not accompanied by recovery information for mercury; data are assumed to be corrected for accuracy.

Table 5-2 (Continued)

Data source	Sample no.	Treated TCLP or EP concentration (mg/l)	Accuracy-correction factor	Accuracy-corrected values (mg/l)
Plant E ^a	123			<0.001
	124			0.013
	125			0.007
	126			0.014
	127			0.056
	128			0.037
	129			0.026
	130			0.016
	131			0.023
	132			0.037
	133			0.037
	134			0.039
	135			0.001
	136			0.039
	137			0.002
	138			0.041
	139			0.072
	140			0.005
	141			0.107
	142			0.036
	143			0.008
	144			0.039
	145			0.014
	146			0.005
	147			0.034
	148			0.004
	149			0.002
	150			0.004
	151			0.008
	152			0.066
	153			0.001
	154			0.004
	155			<0.001
	156			0.002
	157			0.007
	158			0.005
	159			0.018
	160			0.022
	161			0.031
	162			0.014
	163			0.091

^aData were not accompanied by recovery information for mercury; data are assumed to be corrected for accuracy.

Table 5-2 (Continued)

Data source	Sample no.	Treated TCLP or EP concentration (mg/l)	Accuracy-correction factor	Accuracy-corrected values (mg/l)
Plant E ^a	164			0.037
	165			0.164
	166			0.005
	167			0.008
	168			0.004
	169			0.005
	170			0.091
	171			0.011
	172			0.038
	173			0.090
	174			0.065
	175			0.007
	176			0.012
	177			0.020
	178			0.016
	179			0.030
	180			0.114
	181			0.169
	182			0.051
	183			0.012
	184			0.045
	185			0.037
	186			0.027
	187			0.029
	188			0.055
	189			0.115
	190			0.041
	191			0.030
	192			0.033
	193			0.025
	194			0.022
	195			0.040
	196			0.001
	197			0.038
	198			0.016
	199			0.020
	200			0.021
	201			0.038
	202			0.039
	203			0.027
	204			0.023

^aData were not accompanied by recovery information for mercury; data are assumed to be corrected for accuracy.

Table 5-2 (Continued)

Data source	Sample no.	Treated TCLP or EP concentration (mg/l)	Accuracy-correction factor	Accuracy-corrected values (mg/l)
Plant E ^a	205			0.015
	206			0.026
	207			0.023
	208			0.029
	209			0.010
	210			0.023
	211			0.023
	212			0.027
	213			0.032
	214			0.028
	215			0.035
	216			0.027
	217			0.031
	218			0.064
	219			0.031
	220			0.022
	221			0.025
	222			0.035
	223			0.050
	224			0.031
	225			0.026
	226			0.042
	227			0.063
	228			0.044
	229			0.043
	230			0.053
	231			0.022
	232			0.017

^aData were not accompanied by recovery information for mercury; data are assumed to be corrected for accuracy.

Table 5-3 Results of ANOVA Test for Demonstrated Technologies for
K071 Nonwastewater

Summary statistics:

Technology	Data count	Mean	Standard deviation	Minimum	Maximum
1 ^a	371	0.0043	0.0079	0.0002	0.0710
2 ^b	268	0.0206	0.235	0.0004	0.1690

Analysis of variance results:

Source	Degree of freedom	Sum of squares	Mean of squares	F ratio	Critical value
Between groups	1	414.6216	414.6216	332.0964	3.84
Within groups	638	792.3055	1.2418		
Total	639	1204.7222			

^aTechnology 1 is acid leaching followed by chemical oxidation and then sludge dewatering/acid washing.

^bTechnology 2 is sludge dewatering/water washing.

Note: Since the F ratio exceeds the critical value, the means of the two groups of data are significantly different. Technology 1 is considered best because its mean is lower.

Table 5-4 Accuracy-Corrected Mercury Data for Chemical
Precipitation and Filtration

Data source	Sample no.	Treated total concentration (mg/l)	Accuracy-correction factor	Accuracy-correction value (mg/l)
Plant A.1	1	0.028	1/0.95	0.0295
	2	0.027	1/0.95	0.0284
	3	0.028	1/0.95	0.0295

6. SELECTION OF REGULATED CONSTITUENTS

As discussed in Section 1, the Agency has developed a list of hazardous constituents (see Table 1-1) from which the constituents to be regulated are selected. EPA may revise this list as additional data and information become available. The list is divided into the following categories: volatile organics, semivolatile organics, metals, inorganics other than metals, organochlorine pesticides, phenoxyacetic acid herbicides, organophosphorous insecticides, PCBs, and dioxins and furans.

This section describes the process used to select the constituents to be regulated for K071. The process involves developing a list of potential regulated constituents and then eliminating those constituents that would not be treated by the chosen BDAT or that would be controlled by regulation of the remaining constituents.

6.1 Identification of BDAT List Constituents in K071 Waste

As discussed in Sections 2 and 4, the Agency has characterization data as well as performance data from treatment of K071 waste. All these data, along with information on the waste generating process, have been used to determine which BDAT list constituents may be present in the waste and thus which are potential candidates for regulation in K071 nonwastewater and wastewater.

Table 6-1 indicates, for the untreated waste, which constituents were analyzed, which constituents were detected, and which constituents the Agency believes are likely to be present though not detected. Concentrations are shown for constituents that were detected.

Under the column "Believed to be present," constituents other than those detected in the untreated waste are marked with X or Y if EPA believes they are likely to be present in the untreated waste. For those constituents marked with X, an engineering analysis of the waste generating process indicates that they are likely to be present (e.g., the engineering analysis shows that a particular constituent is a major raw material). Those constituents marked with Y have been detected in the treated residual(s) and thus EPA believes that they are present in the untreated waste. Constituents may not have been detected in the untreated waste for one of several reasons: (1) none of the untreated waste samples were analyzed for these constituents, (2) masking or interference by other constituents prevented detection, or (3) the constituent indeed was not present. (With regard to Reason (3), it is important to note that some wastes are defined as being generated from a process. The process may utilize variable starting materials composed of different constituents; therefore, all potentially regulated constituents would not be present in any given sample.)

As shown in Table 6-1, four volatile organics and ten metals were detected in untreated samples. Three additional metals were found in the treated residuals and therefore are believed to be present in the waste. These 17 constituents are the potential candidates for regulation in K071 waste.

6.2 Constituent Selection

Of the 17 candidates for regulation, EPA is regulating mercury. The performance data for nonwastewater indicate that the regulation of

mercury will ensure that barium and nickel concentrations are reduced in the TCLP leachate. EPA believes that the other ten metals may be present in treatable concentrations, but at the respective total or TCLP/EP concentrations, only copper and zinc would be treated by any of the demonstrated technologies for K071 nonwastewater or K071 wastewater. The Agency is not regulating copper and zinc in K071 waste. (These metals are regulated only when they serve as indicators of performance, as explained in the preamble to the final rule for First Thirds wastes.) The four organics were found in one sample at concentrations ranging from 0.062 to 0.550 mg/kg. These constituents are not being regulated because the EPA has no data on K071 waste or any similar waste from which the Agency believes performance data can be transferred.

Note that 136 of the 231 BDAT list constituents were not analyzed. These include 90 volatile and semivolatile organics, hexavalent chromium, cyanide fluoride, sulfide, and the remaining classes of organics (organochlorine pesticides, phenoxyacetic acid herbicides, organophosphorous insecticides, PCBs, and dioxins and furans). EPA does not expect any of these constituents to be present in treatable quantities.

Table 6-1 Status of BDAT List Constituent Presence
in Untreated K071 Waste

BDAT reference no.	Constituent	Detection status ^a	Believed to be present
<u>Volatile organics</u>			
222.	Acetone	NA	
1.	Acetonitrile	NA	
2.	Acrolein	NA	
3.	Acrylonitrile	NA	
4.	Benzene	ND	
5.	Bromodichloromethane	0.062	
6.	Bromomethane	ND	
223.	n-Butyl alcohol	NA	
7.	Carbon tetrachloride	ND	
8.	Carbon disulfide	ND	
9.	Chlorobenzene	ND	
10.	2-Chloro-1,3-butadiene	NA	
11.	Chlorodibromomethane	0.170	
12.	Chloroethane	ND	
13.	2-Chloroethyl vinyl ether	ND	
14.	Chloroform	0.200	
15.	Chloromethane	ND	
16.	3-Chloropropene	NA	
17.	1,2-Dibromo-3-chloropropane	NA	
18.	1,2-Dibromoethane	NA	
19.	Dibromomethane	NA	
20.	trans-1,4-Dichloro-2-butene	NA	
21.	Dichlorodifluoromethane	NA	
22.	1,1-Dichloroethane	ND	
23.	1,2-Dichloroethane	ND	
24.	1,1-Dichloroethylene	ND	
25.	trans-1,2-Dichloroethene	ND	
26.	1,2-Dichloropropane	ND	
27.	trans-1,3-Dichloropropene	ND	
28.	cis-1,3-Dichloropropene	ND	
29.	1,4-Dioxane	NA	
224.	2-Ethoxyethanol	NA	
225.	Ethyl acetate	NA	
226.	Ethyl benzene	NA	
30.	Ethyl cyanide	NA	
227.	Ethyl ether	NA	
31.	Ethyl methacrylate	NA	
214.	Ethylene oxide	NA	
32.	Iodomethane	NA	
33.	Isobutyl alcohol	NA	
228.	Methanol	NA	
34.	Methyl ethyl ketone	NA	

Table 6-1 (Continued)

BDAF reference no.	Constituent	Detection status ^a	Believed to be present
<u>Volatile organics (continued)</u>			
229.	Methyl isobutyl ketone	NA	
35.	Methyl methacrylate	NA	
37.	Methacrylonitrile	NA	
38.	Methylene chloride	ND	
230.	2-Nitropropane	NA	
39.	Pyridine	NA	
40.	1,1,1,2-Tetrachloroethane	NA	
41.	1,1,2,2-Tetrachloroethane	ND	
42.	Tetrachloroethene	ND	
43.	Toluene	ND	
44.	Tribromomethane	0.550	
45.	1,1,1-Trichloroethane	ND	
46.	1,1,2-Trichloroethane	ND	
47.	Trichloroethene	ND	
48.	Trichloromonofluoromethane	NA	
49.	1,2,3-Trichloropropane	NA	
231.	1,1,2-Trichloro-1,2,2-trifluoroethane	NA	
50.	Vinyl chloride	ND	
215.	1,2-Xylene	ND	
216.	1,3-Xylene	ND	
217.	1,4-Xylene	ND	
<u>Semivolatile organics</u>			
51.	Acenaphthalene	ND	
52.	Acenaphthene	ND	
53.	Acetophenone	NA	
54.	2-Acetylamino fluorene	NA	
55.	4-Aminobiphenyl	NA	
56.	Aniline	NA	
57.	Anthracene	ND	
58.	Aramite	NA	
59.	Benz(a)anthracene	ND	
218.	Benzal chloride	NA	
60.	Benzenethiol	NA	
61.	Deleted		
62.	Benzo(a)pyrene	ND	
63.	Benzo(b)fluoranthene	ND	
64.	Benzo(ghi)perylene	ND	
65.	Benzo(k)fluoranthene	ND	
66.	p-Benzoquinone	NA	

Table 6-1 (Continued)

BDAT reference no.	Constituent	Detection status ^a	Believed to be present
<u>Semivolatile organics (continued)</u>			
67.	Bis(2-chloroethoxy)methane	ND	
68.	Bis(2-chloroethyl)ether	ND	
69.	Bis(2-chloroisopropyl)ether	ND	
70.	Bis(2-ethylhexyl)phthalate	ND	
71.	4-Bromophenyl phenyl ether	ND	
72.	Butyl benzyl phthalate	ND	
73.	2-sec-Butyl-4,6-dinitrophenol	NA	
74.	p-Chloroaniline	ND	
75.	Chlorobenzilate	NA	
76.	p-Chloro-m-cresol	NA	
77.	2-Chloronaphthalene	ND	
78.	2-Chlorophenol	ND	
79.	3-Chloropropionitrile	NA	
80.	Chrysene	ND	
81.	ortho-Cresol	NA	
82.	para-Cresol	NA	
232.	Cyclohexanone	NA	
83.	Dibenz(a,h)anthracene	ND	
84.	Dibenzo(a,e)pyrene	NA	
85.	Dibenzo(a,i)pyrene	NA	
86.	m-Dichlorobenzene	ND	
87.	o-Dichlorobenzene	ND	
88.	p-Dichlorobenzene	ND	
89.	3,3'-Dichlorobenzidine	ND	
90.	2,4-Dichlorophenol	ND	
91.	2,6-Dichlorophenol	NA	
92.	Diethyl phthalate	ND	
93.	3,3'-Dimethoxybenzidine	NA	
94.	p-Dimethylaminoazobenzene	NA	
95.	3,3'-Dimethylbenzidine	NA	
96.	2,4-Dimethylphenol	ND	
97.	Dimethyl phthalate	ND	
98.	Di-n-butyl phthalate	ND	
99.	1,4-Dinitrobenzene	NA	
100.	4,6-Dinitro-o-cresol	NA	
101.	2,4-Dinitrophenol	ND	
102.	2,4-Dinitrotoluene	ND	
103.	2,6-Dinitrotoluene	ND	
104.	Di-n-octyl phthalate	ND	
105.	Di-n-propylnitrosamine	NA	
106.	Diphenylamine	NA	
219.	Diphenylnitrosamine	NA	

Table 6-1 (Continued)

BDAT reference no.	Constituent	Detection status ^a	Believed to be present
<u>Semivolatile organics</u> (continued)			
107.	1,2-Diphenylhydrazine	NA	
108.	Fluoranthene	ND	
109.	Fluorene	ND	
110.	Hexachlorobenzene	ND	
111.	Hexachlorobutadiene	ND	
112.	Hexachlorocyclopentadiene	ND	
113.	Hexachloroethane	ND	
114.	Hexachlorophene	NA	
115.	Hexachloropropene	NA	
116.	Indeno(1,2,3-cd)pyrene	ND	
117.	Isosafrole	NA	
118.	Methapyrene	NA	
119.	3-Methylcholanthrene	NA	
120.	4,4'-Methylenebis (2-chloroaniline)	NA	
36.	Methyl methanesulfonate	NA	
121.	Naphthalene	ND	
122.	1,4-Naphthoquinone	NA	
123.	1-Naphthylamine	NA	
124.	2-Naphthylamine	NA	
125.	p-Nitroaniline	ND	
126.	Nitrobenzene	ND	
127.	4-Nitrophenol	ND	
128.	N-Nitrosodi-n-butylamine	NA	
129.	N-Nitrosodiethylamine	NA	
130.	N-Nitrosodimethylamine	NA	
131.	N-Nitrosomethylethylamine	NA	
132.	N-Nitrosomorpholine	NA	
133.	N-Nitrosopiperidine	NA	
134.	n-Nitrosopyrrolidine	NA	
135.	5-Nitro-o-toluidine	NA	
136.	Pentachlorobenzene	NA	
137.	Pentachloroethane	NA	
138.	Pentachloronitrobenzene	NA	
139.	Pentachlorophenol	ND	
140.	Phenacetin	NA	
141.	Phenanthrene	ND	
142.	Phenol	ND	
220.	Phthalic anhydride	NA	
143.	2-Picoline	NA	
144.	Pronamide	NA	
145.	Pyrene	ND	
146.	Resorcinol	NA	

Table 6-1 (Continued)

BDAI reference no.	Constituent	Detection status ^a	Believed to be present
<u>Semivolatile organics (continued)</u>			
147.	Safrole	NA	
148.	1,2,4,5-Tetrachlorobenzene	NA	
149.	2,3,4,6-Tetrachlorophenol	NA	
150.	1,2,4-Trichlorobenzene	ND	
151.	2,4,5-Trichlorophenol	ND	
152.	2,4,6-Trichlorophenol	ND	
153.	Tris(2,3-dibromopropyl) phosphate	NA	
<u>Metals</u>			
154.	Antimony	10	
155.	Arsenic	ND	Y
156.	Barium	0.57-1.4	
157.	Beryllium	ND	
158.	Cadmium	3.8	
159.	Chromium (total)	5.9	
221.	Chromium (hexavalent)	NA	
160.	Copper	184.7	
161.	Lead	47.8	
162.	Mercury	1.12-172.8	
163.	Nickel	3.15-90.3	
164.	Selenium	ND	Y
165.	Silver	ND	Y
166.	Thallium	7.74-<43	
167.	Vanadium	ND	
168.	Zinc	2.29-128.0	
<u>Inorganics other than metals</u>			
169.	Cyanide	NA	
170.	Fluoride	NA	
171.	Sulfide	NA	
<u>Organochlorine pesticides</u>			
172.	Aldrin	NA	
173.	alpha-BHC	NA	
174.	beta-BHC	NA	
175.	delta-BHC	NA	

Table 6-1 (Continued)

BDAT reference no.	Constituent	Detection status ^a	Believed to be present
<u>Organochlorine pesticides (continued)</u>			
176.	gamma-BHC	NA	
177.	Chlordane	NA	
178.	DDD	NA	
179.	DDE	NA	
180.	DDT	NA	
181.	Dieldrin	NA	
182.	Endosulfan I	NA	
183.	Endosulfan II	NA	
184.	Endrin	NA	
185.	Endrin aldehyde	NA	
186.	Heptachlor	NA	
187.	Heptachlor epoxide	NA	
188.	Isodrin	NA	
189.	Kepone	NA	
190.	Methoxychlor	NA	
191.	Toxaphene	NA	
<u>Phenoxyacetic acid herbicides</u>			
192.	2,4-Dichlorophenoxyacetic acid	NA	
193.	Silvex	NA	
194.	2,4,5-T	NA	
<u>Organophosphorous insecticides</u>			
195.	Disulfoton	NA	
196.	Famphur	NA	
197.	Methyl parathion	NA	
198.	Parathion	NA	
199.	Phorate	NA	
<u>PCBs</u>			
200.	Aroclor 1016	NA	
201.	Aroclor 1221	NA	
202.	Aroclor 1232	NA	
203.	Aroclor 1242	NA	
204.	Aroclor 1248	NA	
205.	Aroclor 1254	NA	
206.	Aroclor 1260	NA	

Table 6-1 (Continued)

BDAT reference no.	Constituent	Detection status ^a	Believed to be present
<u>Dioxins and furans</u>			
207.	Hexachlorodibenzo-p-dioxins	NA	
208.	Hexachlorodibenzofurans	NA	
209.	Pentachlorodibenzo-p-dioxins	NA	
210.	Pentachlorodibenzofurans	NA	
211.	Tetrachlorodibenzo-p-dioxins	NA	
212.	Tetrachlorodibenzofurans	NA	
213.	2,3,7,8-Tetrachlorodibenzo- p-dioxin	NA	

ND = Not detected.

NA = Not analyzed.

X = Believed to be present based on engineering analysis of the
waste generating process.

Y = Believed to be present based on detection in treated residuals.

^aIf detected, concentrations are shown; units are mg/kg.

7. CALCULATION OF BDAT TREATMENT STANDARDS

This section details the calculation of treatment standards for the regulated constituent, mercury, selected in Section 6.

For nonwastewater, EPA is setting a treatment standard based on performance data from treatment by acid leaching followed by chemical oxidation and then sludge dewatering/acid washing. As discussed in Section 5, the Agency has 371 data points from this BDAT that the Agency believes reflect treatment in well-designed and well-operated systems. As these data are also accompanied by sufficient QA/QC information, they meet the requirements for setting treatment standards.

For wastewater, the treatment standard is based on performance data from chemical precipitation, using sulfide as the treatment chemical, and filtration. The Agency has three data points from chemical precipitation and filtration that reflect a well-designed and well-operated system, are accompanied by sufficient QA/QC information, and thus meet the requirements for setting treatment standards.

As discussed in Section 1, the calculation of a treatment standard involves (1) adjusting the data points for accuracy, (2) determining the arithmetic average and variability factor for the data points, and (3) multiplying the average and variability factor together to determine the treatment standard.

The data from both the nonwastewater and wastewater BDATs were adjusted in Section 5 prior to determining BDAT (see Tables 5-1 and 5-4). The accuracy-corrected data, as well as the averages of the

values, variability factors, and treatment standards, are presented in Tables 7-1 and 7-2.

Table 7-1 Calculation of Nonwastewater Treatment Standard for Mercury in K071 Waste
Using Performance Data from Acid Leaching Followed by Chemical
Oxidation and Then Sludge Dewatering/Acid Washing

Data source	Sample no.	Accuracy-corrected TCLP	Average	Variability factor	Treatment
		or EP concentration (mg/l)			standard ^a (mg/l)
Plant A.1	1	0.0003	0.0043	5.47	0.025
	2	<0.0002			
	3	-			
	4	0.0002			
	5	0.0005			
	6	0.0017			
	7	<0.0002			
Plant A.2	1	-			
	2	-			
	3	0.008			
	4	-			
	5	<0.002			
	6	<0.002			
	7	0.007			
	8	0.002			
	9	<0.002			
	10	0.012			
	11	0.003			
	12	0.004			
	13	0.002			
	14	<0.002			
	15	<0.002			
	16	<0.002			
	17	0.001			
	18	0.003			
	19	<0.001			
	20	<0.002			
	21	<0.002			
	22	<0.002			
	23	<0.002			
	24	<0.002			
	25	<0.001			
	26	<0.001			
	27	<0.002			
	28	<0.002			
	29	<0.002			
	30	<0.001			

^aNote that the treatment standard will be enforced using the TCLP. The value for the treatment standard was rounded to two significant figures at the end of the calculation.

Table 7-1 (Continued)

Data source	Sample no.	Accuracy-corrected TCLP or EP concentration (mg/l)
Plant A.2	31	0.002
	32	<0.001
	33	<0.001
	34	<0.001
	35	<0.001
	36	<0.001
	37	0.001
	38	0.002
	39	0.001
	40	0.002
	41	0.001
	42	0.009
	43	<0.001
	44	0.012
	45	0.001
	46	<0.001
	47	-
	48	-
	49	-
	50	-
	51	-
	52	<0.001
	53	<0.001
	54	<0.001
	55	0.001
	56	<0.001
	57	<0.001
	58	<0.001
	59	<0.001
	60	<0.001
	61	<0.001
	62	<0.001
	63	0.001
	64	<0.001
	65	<0.001
	66	<0.001
	67	<0.001
	68	<0.001
	69	<0.001
	70	<0.001

Table 7-1 (Continued)

Data source	Sample no.	Accuracy-corrected TCLP or EP concentration (mg/l)
Plant A.2	71	<0.001
	72	<0.001
	73	<0.001
	74	0.001
	75	0.004
	76	<0.001
	77	0.001
	78	0.001
	79	0.004
	80	<0.001
	81	<0.001
	82	<0.001
	83	-
	84	-
	85	0.008
	86	<0.001
	87	0.001
	88	0.001
	89	0.007
	90	-
	91	<0.001
	92	0.006
	93	0.005
	94	0.009
	95	0.001
	96	0.002
	97	<0.001
	98	0.002
	99	0.002
	100	0.004
	101	0.002
	102	0.002
	103	0.001
	104	0.001
	105	0.001
	106	0.005
	107	0.005
	108	0.003
	109	0.003
	110	0.002

Table 7-1 (Continued)

Data source	Sample no.	Accuracy-corrected TCLP or EP concentration (mg/l)
Plant A.2	111	<0.001
	112	<0.001
	113	<0.001
	114	<0.001
	115	0.001
	116	<0.001
	117	<0.001
	118	<0.001
	119	<0.001
	120	0.001
	121	-
	122	<0.001
	123	0.003
	124	0.006
	125	<0.001
	126	0.002
	127	<0.001
	128	<0.001
	129	0.002
	130	<0.001
	131	<0.001
	132	<0.001
	133	0.001
	134	<0.001
	135	0.001
	136	<0.001
	137	<0.001
	138	<0.001
	139	<0.001
	140	0.003
	141	0.003
	142	0.001
	143	0.006
	144	0.003
	145	<0.001
	146	0.001
	147	<0.001
	149	<0.001
	150	<0.002
	151	0.003

Table 7-1 (Continued)

Data source	Sample no.	Accuracy-corrected TCLP or EP concentration (mg/l)
Plant A.2	152	-
	153	-
	154	-
	155	0.002
	156	<0.001
	157	<0.001
	158	<0.001
	159	<0.001
	160	0.001
	161	-
	162	-
	163	-
	164	0.011
	165	<0.001
	166	<0.001
	167	-
	168	0.008
	169	0.007
	170	<0.001
	171	<0.001
	172	-
	173	-
	174	-
	175	0.006
	176	0.007
	177	0.001
	178	<0.001
	179	-
	180	0.004
	181	0.008
	182	0.005
	183	0.003
	184	0.001
	185	0.005
	186	0.007
	187	0.002
	188	-
	189	0.010
	190	0.001
	191	0.008

Table 7-1 (Continued)

Data source	Sample no.	Accuracy-corrected TCLP or EP concentration (mg/l)
Plant A.2	192	0.005
	193	0.012
	194	0.002
	195	0.002
	196	-
	197	0.040
	198	-
	199	0.011
	200	-
	201	0.032
	202	0.031
	203	0.014
	204	0.003
	205	0.003
	206	0.012
	207	0.008
	208	0.002
	209	0.007
	210	0.005
	211	0.003
	212	0.012
	213	0.004
	214	0.004
	215	<0.001
	216	0.010
	217	<0.001
	218	0.002
	219	-
	220	0.010
	221	0.010
	222	0.005
	223	0.002
	224	0.002
	225	0.002
	226	0.005
	227	-
	228	0.001
	229	0.003
	230	0.068
	231	0.003

Table 7-1 (Continued)

Data source	Sample no.	Accuracy-corrected TCLP or EP concentration (mg/l)
Plant A.2	232	<0.001
	233	0.009
	234	0.009
	235	0.005
	236	0.005
	237	0.003
	238	0.002
	239	0.008
	240	0.002
	241	0.008
	242	0.032
	243	0.012
	244	0.011
	245	0.003
	246	0.006
	247	0.028
	248	0.003
	249	0.001
	250	0.006
	251	<0.001
	252	<0.001
	253	<0.001
	254	0.001
	255	0.003
	256	0.006
	257	0.002
	258	0.001
	259	0.010
	260	0.006
	261	0.005
	262	0.011
	263	0.007
	264	0.011
	265	0.002
	266	-
	267	0.004
	268	0.021
	269	0.005
	270	0.003
	271	-

Table 7-1 (Continued)

Data source	Sample no.	Accuracy-corrected TCLP or EP concentration (mg/l)
Plant A.2	272	0.009
	273	0.004
	274	0.004
	275	-
	276	0.008
	277	0.002
	278	0.001
	279	<0.001
	280	<0.001
	281	<0.001
	282	0.001
	283	0.006
	284	0.004
	285	0.010
	286	0.002
	287	0.003
	288	0.004
	289	<0.001
	290	<0.001
	291	<0.001
	292	0.001
	293	<0.001
	294	<0.001
	295	<0.001
	296	<0.001
	297	<0.001
	298	<0.001
	299	<0.001
	300	0.008
	301	<0.001
	302	0.001
	303	0.008
	304	0.001
	305	0.001
	306	0.003
	307	<0.001
	308	0.002
	309	<0.001
	310	<0.001
	311	<0.001

Table 7-1 (Continued)

Data source	Sample no.	Accuracy-corrected TCLP or EP concentration (mg/l)
Plant A.2	312	<0.001
	313	0.002
	314	0.008
	315	0.003
	316	0.005
	317	<0.001
	318	<0.001
	319	<0.001
	320	<0.001
	321	0.004
	322	0.001
	323	0.002
	324	0.001
	325	<0.001
	326	<0.001
	327	0.001
	328	0.002
	329	<0.001
	330	0.002
	331	<0.001
	332	0.004
	333	0.004
	334	<0.001
	335	-
	336	0.001
	337	0.001
	338	<0.001
	339	<0.001
	340	<0.001
	341	<0.001
	342	<0.001
	343	0.001
	344	0.001
	345	0.001
	346	0.001
	347	<0.001
	348	0.001
	349	0.001
	350	<0.001
	351	0.003
	352	<0.001
	353	<0.001

Table 7-1 (Continued)

Data source	Sample no.	Accuracy-corrected TCLP or EP concentration (mg/l)
Plant A.2	354	0.004
	355	0.008
	356	0.001
	357	0.001
	358	<0.001
	359	0.008
	360	<0.001
	361	<0.001
	362	0.004
	363	0.002
	364	0.001
	365	<0.001
	366	<0.001
	367	<0.001
	368	0.001
	369	<0.001
	370	<0.001
	371	<0.001
	372	<0.001
	373	0.001
	374	<0.001
	375	<0.001
	376	0.001
	377	0.003
	378	0.011
	379	0.002
Plant B	1	0.0047
	2	0.0208
	3	0.0054
	4	0.0030
	5	0.0096
	6	0.0092
	7	0.0085
	8	0.0175
	9	0.0164
	10	0.0098
	11	0.0140
	12	0.0113
	13	0.0131

Table 7-1 (Continued)

Data source	Sample no.	Accuracy-corrected TCLP or EP concentration (mg/l)
Plant B	14	0.0710
	15	0.0480
	16	0.0090
	17	0.0020
	18	0.0661
	19	0.0087

^aNote that the treatment standard will be enforced using the TCLP. The value for the treatment standard was rounded to two significant figures at the end of the calculation.

Table 7-2 Calculation of Wastewater Treatment Standard for Mercury
in K071 Waste Using Performance Data from
Chemical Precipitation and Filtration

Data source	Sample no.	Accuracy-corrected total concentration (mg/l)	Average	Variability factor	Treatment standard ^a (mg/l)
Plant A.1	1	0.0295	0.0291	1.05	0.030
	2	0.0284			
	3	0.0295			

^aThe value for the treatment standard was rounded to two significant figures at the end of the calculation.

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APPENDIX A

STATISTICAL METHODS

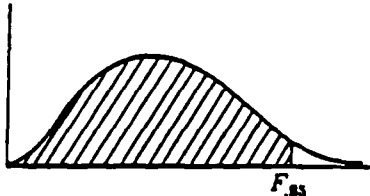
A.1 F Value Determination for ANOVA Test

As noted in Section 1.2, EPA is using the statistical method known as analysis of variance (ANOVA) to determine the level of performance that represents "best" treatment where more than one technology is demonstrated. This method provides a measure of the differences between data sets.

If the Agency found that the levels of performance for one or more technologies are not statistically different (i.e., the data sets are homogeneous), EPA would average the long-term performance values achieved by each technology and then multiply this value by the largest variability factor associated with any of the acceptable technologies. If EPA found that one technology performs significantly better (i.e., the data sets are not homogeneous), the "best" technology would be the technology that achieves the best level of performance, i.e., the technology with the lowest mean value.

To determine whether any or all of the treatment performance data sets are homogeneous using the analysis of variance method, it is necessary to compare a calculated "F value" to what is known as a "critical value." (See Table A-1.) These critical values are available in most statistics texts (see, for example, Statistical Concepts and Methods by Bhattacharyya and Johnson, 1977, John Wiley Publications, New York).

Table A-1

	<p align="center">95th PERCENTILE VALUES FOR THE F DISTRIBUTION</p> <p>n_1 = degrees of freedom for numerator n_2 = degrees of freedom for denominator (shaded area = .95)</p>	
--	--	---

$n_1 \backslash n_2$	1	2	3	4	5	6	8	12	16	20	30	40	50	100	∞
1	161.4	199.5	215.7	224.6	230.2	234.0	238.9	243.9	246.3	248.0	250.1	251.1	252.2	253.0	254.3
2	18.51	19.00	19.16	19.25	19.30	19.33	19.37	19.41	19.43	19.45	19.46	19.46	19.47	19.49	19.50
3	10.13	9.55	9.28	9.12	9.01	8.94	8.85	8.74	8.69	8.66	8.62	8.60	8.58	8.56	8.53
4	7.71	6.94	6.59	6.39	6.26	6.16	6.04	5.91	5.84	5.80	5.75	5.71	5.70	5.66	5.63
5	6.61	5.79	5.41	5.19	5.05	4.95	4.82	4.68	4.60	4.56	4.50	4.46	4.44	4.40	4.36
6	5.99	5.14	4.76	4.53	4.39	4.28	4.15	4.00	3.92	3.87	3.81	3.77	3.75	3.71	3.67
7	5.59	4.74	4.35	4.12	3.97	3.87	3.73	3.57	3.49	3.44	3.38	3.34	3.32	3.28	3.23
8	5.32	4.46	4.07	3.84	3.69	3.58	3.44	3.28	3.20	3.15	3.08	3.05	3.03	2.98	2.93
9	5.12	4.26	3.86	3.63	3.48	3.37	3.23	3.07	2.98	2.93	2.86	2.82	2.80	2.76	2.71
10	4.96	4.10	3.71	3.48	3.33	3.22	3.07	2.91	2.82	2.77	2.70	2.67	2.64	2.59	2.54
11	4.84	3.98	3.59	3.36	3.20	3.09	2.95	2.79	2.70	2.65	2.57	2.53	2.50	2.45	2.40
12	4.75	3.89	3.49	3.26	3.11	3.00	2.85	2.69	2.60	2.54	2.46	2.42	2.40	2.35	2.30
13	4.67	3.81	3.41	3.18	3.03	2.92	2.77	2.60	2.51	2.46	2.38	2.34	2.32	2.26	2.21
14	4.60	3.74	3.34	3.11	2.96	2.85	2.70	2.53	2.44	2.39	2.31	2.27	2.24	2.19	2.13
15	4.54	3.68	3.29	3.06	2.90	2.79	2.64	2.48	2.39	2.33	2.25	2.21	2.18	2.12	2.07
16	4.49	3.63	3.24	3.01	2.85	2.74	2.59	2.42	2.33	2.28	2.20	2.16	2.13	2.07	2.01
17	4.45	3.59	3.20	2.96	2.81	2.70	2.55	2.38	2.29	2.23	2.15	2.11	2.08	2.02	1.96
18	4.41	3.55	3.16	2.93	2.77	2.66	2.51	2.34	2.25	2.19	2.11	2.07	2.04	1.98	1.92
19	4.38	3.52	3.13	2.90	2.74	2.63	2.48	2.31	2.21	2.15	2.07	2.02	2.00	1.94	1.88
20	4.35	3.49	3.10	2.87	2.71	2.60	2.45	2.28	2.18	2.12	2.04	1.99	1.96	1.90	1.84
22	4.30	3.44	3.05	2.82	2.66	2.55	2.40	2.23	2.13	2.07	1.98	1.93	1.91	1.84	1.78
24	4.26	3.40	3.01	2.78	2.62	2.51	2.36	2.18	2.09	2.03	1.94	1.89	1.86	1.80	1.73
26	4.23	3.37	2.98	2.74	2.59	2.47	2.32	2.15	2.05	1.99	1.90	1.85	1.82	1.76	1.69
28	4.20	3.34	2.95	2.71	2.56	2.45	2.29	2.12	2.02	1.96	1.87	1.81	1.78	1.72	1.65
30	4.17	3.32	2.92	2.69	2.53	2.42	2.27	2.09	1.99	1.93	1.84	1.79	1.76	1.69	1.62
40	4.08	3.23	2.84	2.61	2.45	2.34	2.18	2.00	1.90	1.84	1.74	1.69	1.66	1.59	1.51
50	4.03	3.18	2.79	2.56	2.40	2.29	2.13	1.95	1.85	1.78	1.69	1.63	1.60	1.52	1.44
60	4.00	3.15	2.76	2.53	2.37	2.25	2.10	1.92	1.81	1.75	1.65	1.59	1.56	1.48	1.39
70	3.98	3.13	2.74	2.50	2.35	2.23	2.07	1.89	1.79	1.72	1.62	1.56	1.53	1.45	1.35
80	3.96	3.11	2.72	2.48	2.33	2.21	2.05	1.88	1.77	1.70	1.60	1.54	1.51	1.42	1.32
100	3.94	3.09	2.70	2.46	2.30	2.19	2.03	1.85	1.75	1.68	1.57	1.51	1.48	1.39	1.28
150	3.91	3.06	2.67	2.43	2.27	2.16	2.00	1.82	1.71	1.64	1.54	1.47	1.44	1.34	1.22
200	3.89	3.04	2.65	2.41	2.26	2.14	1.98	1.80	1.69	1.62	1.52	1.45	1.42	1.32	1.19
400	3.86	3.02	2.62	2.39	2.23	2.12	1.96	1.78	1.67	1.60	1.49	1.42	1.38	1.28	1.13
∞	3.84	2.99	2.60	2.37	2.21	2.09	1.94	1.75	1.64	1.57	1.46	1.40	1.32	1.24	1.00

Where the F value is less than the critical value, all treatment data sets are homogeneous. If the F value exceeds the critical value, it is necessary to perform a "pair wise F" test to determine if any of the sets are homogeneous. The "pair wise F" test must be done for all of the various combinations of data sets using the same method and equation as the general F test.

The F value is calculated as follows:

- (i) All data are natural logtransformed.
- (ii) The sum of the data points for each data set is computed (T_i).
- (iii) The statistical parameter known as the sum of the squares

between data sets (SSB) is computed:

$$SSB = \left[\sum_{i=1}^k \left(\frac{T_i^2}{n_i} \right) \right] - \left[\frac{\left(\sum_{i=1}^k T_i \right)^2}{N} \right]$$

where:

- k = number of treatment technologies
- n_i = number of data points for technology i
- N = number of data points for all technologies
- T_i = sum of natural logtransformed data points for each technology.

- (iv) The sum of the squares within data sets (SSW) is computed:

$$SSW = \left[\sum_{i=1}^k \sum_{j=1}^{n_i} x_{i,j}^2 \right] - \sum_{i=1}^k \left(\frac{T_i^2}{n_i} \right)$$

where:

- $x_{i,j}$ = the natural logtransformed observations (j) for treatment technology (i).

(v) The degrees of freedom corresponding to SSB and SSW are calculated. For SSB, the degree of freedom is given by $k-1$. For SSW, the degree of freedom is given by $N-k$.

(vi) Using the above parameters, the F value is calculated as follows:

$$F = \frac{MSB}{MSW}$$

where:

$MSB = SSB/(k-1)$ and
 $MSW = SSW/(N-k)$.

A computational table summarizing the above parameters is shown below.

Computational Table for the F Value

Source	Degrees of freedom	Sum of squares	Mean square	F value
Between	$k-1$	SSB	$MSB = SSB/k-1$	MSB/MSW
Within	$N-k$	SSW	$MSW = SSW/N-k$	

Below are three examples of the ANOVA calculation. The first two represent treatment by different technologies that achieve statistically similar treatment; the last example represents a case in which one technology achieves significantly better treatment than the other technology.

Example 1
Methylene Chloride

<u>Steam stripping</u>				<u>Biological treatment</u>			
Influent ($\mu\text{g/l}$)	Effluent ($\mu\text{g/l}$)	$\ln(\text{effluent})$	$[\ln(\text{effluent})]^2$	Influent ($\mu\text{g/l}$)	Effluent ($\mu\text{g/l}$)	$\ln(\text{effluent})$	$[\ln(\text{effluent})]^2$
1550.00	10.00	2.30	5.29	1960.00	10.00	2.30	5.29
1290.00	10.00	2.30	5.29	2568.00	10.00	2.30	5.29
1640.00	10.00	2.30	5.29	1817.00	10.00	2.30	5.29
5100.00	12.00	2.48	6.15	1640.00	26.00	3.26	10.63
1450.00	10.00	2.30	5.29	3907.00	10.00	2.30	5.29
4600.00	10.00	2.30	5.29				
1760.00	10.00	2.30	5.29				
2400.00	10.00	2.30	5.29				
4800.00	10.00	2.30	5.29				
12100.00	10.00	2.30	5.29				
Sum:							
-	-	23.18	53.76	-	-	12.46	31.79
Sample Size:							
10	10	10	-	5	5	5	-
Mean:							
3669	10.2	2.32	-	2378	13.2	2.49	-
Standard Deviation:							
3328.67	.63	.06	-	923.04	7.15	.43	-
Variability Factor:							
	1.15	-	-		2.48	-	-

ANOVA Calculations:

$$SSB = \left[\sum_{i=1}^k \left(\frac{T_i^2}{n_i} \right) \right] - \left[\frac{\left(\sum_{i=1}^k T_i \right)^2}{N} \right]$$

$$SSW = \left[\sum_{i=1}^k \sum_{j=1}^{n_i} x_{i,j}^2 \right] - \sum_{i=1}^k \left(\frac{T_i^2}{n_i} \right)$$

$$MSB = SSB/(k-1)$$

$$MSW = SSW/(N-k)$$

Example 1 (Continued)

$$F = MSB/MSW$$

where:

k = number of treatment technologies

n_i = number of data points for technology i

N = number of natural logtransformed data points for all technologies

T_i = sum of logtransformed data points for each technology

X_{ij} = the nat. logtransformed observations (j) for treatment technology (i)

$$n_1 = 10, n_2 = 5, N = 15, k = 2, T_1 = 23.18, T_2 = 12.46, T = 35.64, T^2 = 1270.21$$

$$T_1^2 = 537.31 \quad T_2^2 = 155.25$$

$$SSB = \left(\frac{537.31}{10} + \frac{155.25}{5} \right) - \frac{1270.21}{15} = 0.10$$

$$SSW = (53.76 + 31.79) - \left(\frac{537.31}{10} + \frac{155.25}{5} \right) = 0.77$$

$$MSB = 0.10/1 = 0.10$$

$$MSW = 0.77/13 = 0.06$$

$$F = \frac{0.10}{0.06} = 1.67$$

ANOVA Table

Source	Degrees of freedom	SS	MS	F value
Between(B)	1	0.10	0.10	1.67
Within(W)	13	0.77	0.06	

The critical value of the F test at the 0.05 significance level is 4.67. Since the F value is less than the critical value, the means are not significantly different (i.e., they are homogeneous).

Note: All calculations were rounded to two decimal places. Results may differ depending upon the number of decimal places used in each step of the calculations.

Example 2
Trichloroethylene

<u>Steam stripping</u>				<u>Biological treatment</u>			
Influent ($\mu\text{g/l}$)	Effluent ($\mu\text{g/l}$)	$\ln(\text{effluent})$	$[\ln(\text{effluent})]^2$	Influent ($\mu\text{g/l}$)	Effluent ($\mu\text{g/l}$)	$\ln(\text{effluent})$	$[\ln(\text{effluent})]^2$
1650.00	10.00	2.30	5.29	200.00	10.00	2.30	5.29
5200.00	10.00	2.30	5.29	224.00	10.00	2.30	5.29
5000.00	10.00	2.30	5.29	134.00	10.00	2.30	5.29
1720.00	10.00	2.30	5.29	150.00	10.00	2.30	5.29
1560.00	10.00	2.30	5.29	484.00	16.25	2.79	7.78
10300.00	10.00	2.30	5.29	163.00	10.00	2.30	5.29
210.00	10.00	2.30	5.29	182.00	10.00	2.30	5.29
1600.00	27.00	3.30	10.89				
204.00	85.00	4.44	19.71				
160.00	10.00	2.30	5.29				
Sum:							
-	-	26.14	72.92	-	-	16.59	39.52
Sample Size:							
10	10	10	-	7	7	7	-
Mean:							
2760	19.2	2.61	-	220	10.89	2.37	-
Standard Deviation:							
3209.6	23.7	.71	-	120.5	2.36	.19	-
Variability Factor:							
-	3.70	-	-	-	1.53	-	-

ANOVA Calculations:

$$SSB = \left[\sum_{i=1}^k \left(\frac{T_i^2}{n_i} \right) \right] - \left[\frac{\left(\sum_{i=1}^k T_i \right)^2}{N} \right]$$

$$SSW = \left[\sum_{i=1}^k \sum_{j=1}^{n_i} x_{i,j}^2 \right] - \sum_{i=1}^k \left(\frac{T_i^2}{n_i} \right)$$

$$MSB = SSB/(k-1)$$

$$MSW = SSW/(N-k)$$

Example 2 (Continued)

$$F = MSB/MSW$$

where:

k = number of treatment technologies

n_i = number of data points for technology i

N = number of data points for all technologies

T_i = sum of natural logtransformed data points for each technology

X_{ij} = the natural logtransformed observations (j) for treatment technology (i)

$$N_1 = 10, N_2 = 7, N = 17, k = 2, T_1 = 26.14, T_2 = 16.59, T = 42.73, T^2 = 1825.85, T_1^2 = 683.30,$$

$$T_2^2 = 275.23$$

$$SSB = \left(\frac{683.30}{10} + \frac{275.23}{7} \right) - \frac{1825.85}{17} = 0.25$$

$$SSW = (72.92 + 39.52) - \left(\frac{683.30}{10} + \frac{275.23}{7} \right) = 4.79$$

$$MSB = 0.25/1 = 0.25$$

$$MSW = 4.79/15 = 0.32$$

$$F = \frac{0.25}{0.32} = 0.78$$

ANOVA Table

Source	Degrees of freedom	SS	MS	F value
Between(B)	1	0.25	0.25	0.78
Within(W)	15	4.79	0.32	

The critical value of the F test at the 0.05 significance level is 4.54. Since the F value is less than the critical value, the means are not significantly different (i.e., they are homogeneous).

Note: All calculations were rounded to two decimal places. Results may differ depending upon the number of decimal places used in each step of the calculations.

Example 3
Chlorobenzene

Activated sludge followed by carbon adsorption				Biological treatment			
Influent ($\mu\text{g/l}$)	Effluent ($\mu\text{g/l}$)	$\ln(\text{effluent})$	$[\ln(\text{effluent})]^2$	Influent ($\mu\text{g/l}$)	Effluent ($\mu\text{g/l}$)	$\ln(\text{effluent})$	$\ln[(\text{effluent})]^2$
7200.00	80.00	4.38	19.18	9206.00	1083.00	6.99	48.86
6500.00	70.00	4.25	18.06	16646.00	709.50	6.56	43.03
6075.00	35.00	3.56	12.67	49775.00	460.00	6.13	37.58
3040.00	10.00	2.30	5.29	14731.00	142.00	4.96	24.60
				3159.00	603.00	6.40	40.96
				6756.00	153.00	5.03	25.30
				3040.00	17.00	2.83	8.01

Sum:	-	-	14.49	55.20	-	-	38.90	228.34
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Sample Size:	4	4	4	-	7	7	7	-
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Mean:	5703	49	3.62	-	14759	452.5	5.56	-
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Standard Deviation:	1835.4	32.24	.95	-	16311.86	379.04	1.42	-
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Variability Factor:	-	7.00	-	-	-	15.79	-	-
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ANOVA Calculations:

$$SSB = \left[\sum_{i=1}^k \left(\frac{T_i^2}{n_i} \right) \right] - \left[\frac{\left(\sum_{i=1}^k T_i \right)^2}{N} \right]$$

$$SSW = \left[\sum_{i=1}^k \sum_{j=1}^{n_i} x_{i,j}^2 \right] - \sum_{i=1}^k \left(\frac{T_i^2}{n_i} \right)$$

$$MSB = SSB/(k-1)$$

$$MSW = SSW/(N-k)$$

$$F = MSB/MSW$$

Example 3 (Continued)

where,

k = number of treatment technologies

n_i = number of data points for technology i

N = number of data points for all technologies

T_i = sum of natural logtransformed data points for each technology

x_{ij} = the natural logtransformed observations (j) for treatment technology (i)

$$N_1 = 4, N_2 = 7, N = 11, k = 2, T_1 = 14.49, T_2 = 38.90, T = 53.39, T_1^2 = 2850.49, T_1^2 = 209.96$$

$$T_2^2 = 1513.21$$

$$SSB = \left(\frac{209.96}{4} + \frac{1513.21}{7} \right) - \frac{2850.49}{11} = 9.52$$

$$SSW = (55.20 + 228.34) - \left(\frac{209.96}{4} + \frac{1513.21}{7} \right) = 14.88$$

$$MSB = 9.52/1 = 9.52$$

$$MSW = 14.88/9 = 1.65$$

$$F = 9.52/1.65 = 5.77$$

ANOVA Table

Source	Degrees of freedom	SS	MS	F value
Between(B)	1	9.53	9.53	5.77
Within(W)	9	14.89	1.65	

The critical value of the F test at the 0.05 significance level is 5.12. Since the F value is larger than the critical value, the means are significantly different (i.e., they are heterogeneous). Activated sludge followed by carbon adsorption is "best" in this example because the mean of the long-term performance value, i.e., the effluent concentration, is lower.

Note: All calculations were rounded to two decimal places. Results may differ depending upon the number of decimal places used in each step of the calculations.

A.2 Variability Factor

$$VF = \frac{C_{99}}{\text{Mean}}$$

where:

- VF = estimate of daily maximum variability factor determined from a sample population of daily data;
- C₉₉ = estimate of performance values for which 99 percent of the daily observations will be below. C₉₉ is calculated using the following equation: $C_{99} = \text{Exp}(y + 2.33 S_y)$ where y and S_y are the mean and standard deviation, respectively, of the logtransformed data; and
- Mean = average of the individual performance values.

EPA is establishing this figure as an instantaneous maximum because the Agency believes that on a day-to-day basis the waste should meet the applicable treatment standards. In addition, establishing this requirement makes it easier to check compliance on a single day. The 99th percentile is appropriate because it accounts for almost all process variability.

In several cases, all the results from analysis of the residuals from BDAT treatment are found at concentrations less than the detection limit. In such cases, all the actual concentration values are considered unknown and, hence, cannot be used to estimate the variability factor of the analytical results. Below is a description of EPA's approach for calculating the variability factor for such cases with all concentrations below the detection limit.

It has been postulated as a general rule that a lognormal distribution adequately describes the variation among concentrations. Agency data show that the treatment residual concentrations are

distributed approximately lognormally. Therefore, the lognormal model has been used routinely in the EPA development of numerous regulations in the Effluent Guidelines program and is being used in the BDAT program. The variability factor (VF) was defined as the ratio of the 99th percentile (C_{99}) of the lognormal distribution to its arithmetic mean (Mean), as follows:

$$VF = \frac{C_{99}}{\text{Mean}}. \quad (1)$$

The relationship between the parameters of the lognormal distribution and the parameters of the normal distribution created by taking the natural logarithms of the lognormally distributed concentrations can be found in most mathematical statistics texts (see, for example, Distribution in Statistics-Volume 1 by Johnson and Kotz, 1970). The mean of the lognormal distribution can be expressed in terms of the mean (μ) and standard deviation (σ) of the normal distribution as follows:

$$C_{99} = \text{Exp} (\mu + 2.33\sigma) \quad (2)$$

$$\text{Mean} = \text{Exp} (\mu + 0.5\sigma^2). \quad (3)$$

By substituting (2) and (3) in (1), the variability factor can then be expressed in terms of σ as follows:

$$VF = \text{Exp} (2.33 \sigma - 0.5\sigma^2). \quad (4)$$

For residuals with concentrations that are not all below the detection limit, the 99th percentile and the mean can be estimated from the actual analytical data and, accordingly, the variability factor (VF) can be estimated using equation (1). For residuals with concentrations

that are below the detection limit, the above equations can be used in conjunction with the following assumptions to develop a variability factor.

- Assumption 1: The actual concentrations follow a lognormal distribution. The upper limit (UL) is equal to the detection limit. The lower limit (LL) is assumed to be equal to one-tenth of the detection limit. This assumption is based on the fact that data from well-designed and well-operated treatment systems generally fall within one order of magnitude.
- Assumption 2: The natural logarithms of the concentrations have a normal distribution with an upper limit equal to $\ln(UL)$ and a lower limit equal to $\ln(LL)$.
- Assumption 3: The standard deviation (σ) of the normal distribution is approximated by:

$$\begin{aligned}\sigma &= [\ln(UL) - \ln(LL)] / [(2)(2.33)] \\ &= [\ln(UL/LL)] / 4.66.\end{aligned}\tag{5}$$

(Note that when $LL = (0.1)(UL)$ as in Assumption 1, then $\sigma = (\ln 10) / 4.66 = 0.494$.)

Substitution of the σ value from equation (5) into equation (4) yields the variability factor, VF, as shown:

$$VF = 2.8.\tag{6}$$

APPENDIX B

ANALYTICAL QA/QC

The analytical methods used for analysis of the regulated constituents identified in Section 5 are listed in Table B-1. SW-846 methods (EPA's Test Methods for Evaluating Solid Waste; Physical/Chemical Methods, SW-846, Third Edition, November 1986) are used in most cases for determining total constituent concentrations. Leachate concentrations are to be determined using the Toxicity Characteristic Leaching Procedure (TCLP), published in 51 FR 40643, November 7, 1986.

SW-846 allows for the use of alternative or equivalent procedures or equipment; these are noted in Table B-2. These alternatives or equivalents included use of alternative sample preparation methods and/or use of different extraction techniques to reduce sample matrix interferences.

The accuracy determination for a constituent is based on the matrix spike recovery values. Tables B-3 and B-4 present the matrix spike recoveries for mercury for both total composition and TCLP analyses for K071 residuals for the EPA-collected data. Matrix spike recoveries for total composition, TCLP, and EP toxicity analyses for data submitted by Plants A and B are presented in Tables B-5 through B-8.

The accuracy-correction factors for mercury for each treatment residual are summarized in Tables B-3 through B-8. The accuracy-correction factors were determined in accordance with the general methodology presented in the Introduction. For example, for mercury,

actual spike recovery data were obtained for analysis of both solid and liquid matrices, and the lowest percent recovery value was used to calculate the accuracy-correction factor. An example of the calculation of a corrected constituent concentration value is shown below.

<u>Analytical value</u>	<u>% Recovery</u>	<u>Correction factor</u>	<u>Corrected value</u>
0.0016 mg/l	95	$\frac{100}{95} = 1.05$	$1.05 \times 0.0016 = 0.0017 \text{ mg/l}$

Table B-1 Analytical Methods for Regulated Constituents

Constituent	Extraction method	Analytical method		Reference
Mercury, total concentration	Specified in analytical method	Mercury in Liquid Waste (Manual Cold-Vapor Technique)	7470	1
	Specified in analytical method	Mercury in Solid or Semisolid Waste (Manual Cold-Vapor Technique)	7471	1
Mercury, TCLP leachate		Toxicity Characteristic Leaching Procedure (TCLP)	51 FR 40643	2
	Specified in analytical method	Mercury in Liquid Waste (Manual Cold-Vapor Technique)	7470	1

References:

- (1) USEPA 1986b.
- (2) USEPA 1986c.

Table B-2 Specific Procedures or Equipment Used in Mercury Analysis
When Alternatives or Equivalents Are Allowed in the SW-846 Methods

Constituent	Analysis Method	Equipment	Alternatives or equivalents allowed by SW-846 method	Specific procedures or equipment used
Mercury	7470 7471	Perkin Elmer 50A	<ul style="list-style-type: none"> • Operate equipment according to instructions by instrument manufacturer. • Use cold vapor apparatus as described in SW-846 or an equivalent apparatus. • Prepare samples using the water bath method or the autoclave method, both described in SW-846. 	<ul style="list-style-type: none"> • Equipment was operated using procedures specified in Perkin Elmer 50A Instructions Manual. • Mercury was analyzed by cold-vapor method using the apparatus as specified in SW-846, except that there was no scrubber. • Samples were prepared using the water bath method.

Reference: USEPA 1988a, Table 6-7.

Table B-3 Matrix Spike Recoveries for Solid Waste Matrix - Plant A.1

BDAT constituent	Original amount found (mg/kg)	Sample result			Duplicate result			Accuracy- correction factor ^b
		Spike added (mg/kg)	Spike result (mg/kg)	Percent recovery ^a	Spike added (mg/kg)	Spike result (mg/kg)	Percent recovery ^a	
Mercury	1.1	2.0	3.6	125	2.0	3.7	130	0.080

NC = Not calculable.

^aPercent recovery = [(spike result - original amount)/spike added].

^bAccuracy-correction factor = 100/percent recovery (using the lowest percent recovery value).

Note: Matrix spike data were obtained from untreated K071 waste (Sample Set #8).

Table B-4 Matrix Spike Recoveries for Treated TCLP Leachate Nonwastewater and Wastewater - Plant A.1

GDAT constituent	Original amount found (ug/l)	Sample Set #6			Sample Set #6 duplicate			Accuracy- correction factor ^b
		Spike added (ug/l)	Spike result (ug/l)	Percent recovery ^a	Spike added (ug/l)	Spike result (ug/l)	Percent recovery ^a	
Mercury	1.6	4.0	5.4	95	4.0	5.5	98	1.05

NC = Not calculable.

^aPercent recovery = [(spike result - original amount)/spike added].

^bAccuracy-correction factor = 100/percent recovery (using the lowest percent recovery value).

Reference: USEPA 1988a. Table 6-16.

Table B-5 Matrix Spike Recoveries for Treated Residual - Plant C

BDAT constituent	Original amount found (mg/kg)	Sample result			Accuracy- correction factor ^b
		Spike added (mg/kg)	Spike result (mg/kg)	Percent recovery ^a	
<u>Sample #3:</u>					
Mercury	78	0.4	NR	106	1.0
<u>Sample #8:</u>					
Mercury	92	0.4	NR	88	1.14

NR = Not reported.

^aPercent recovery = [(spike result - original amount)/spike added].

^bAccuracy-correction factor = 100/percent recovery (using the lowest percent recovery value).

Reference: Occidental Chemical Corporation 1987a.

Table B-6 Matrix Spike Recoveries for Treated Nonwastewater TCLP and EP Leachates - Plant C

BDAI constituent	Original amount found (ug/l)	Sample result			Duplicate result			Accuracy- correction factor ^b
		Spike added (ug/l)	Spike result (ug/l)	Percent recovery ^a	Spike added (ug/l)	Spike result (ug/l)	Percent recovery ^a	
<u>Sample #1 - EP Toxicity:</u>								
Mercury	13	0.2	NR	124	0.4	NR	112	1.0
<u>Sample #1 - TCLP:</u>								
Mercury	14	0.2	NR	95	0.4	NR	97	1.05
<u>Sample #2 - EP Toxicity:</u>								
Mercury	14	0.2	NR	117	0.4	NR	121	1.0
<u>Sample #3 - EP Toxicity:</u>								
Mercury	18	0.2	NR	104	0.4	NR	115	1.0
<u>Sample #4 - EP Toxicity:</u>								
Mercury	13	0.2	NR	120	0.4	NR	112	1.0
<u>Sample #5 - EP Toxicity:</u>								
Mercury	24	0.2	NR	81	0.4	NR	84	1.23
<u>Sample #6 - EP Toxicity:</u>								
Mercury	21	0.2	NR	94	0.4	NR	79	1.27
<u>Sample #7 - EP Toxicity:</u>								
Mercury	11	0.2	NR	76	0.4	NR	105	1.32
<u>Sample #8 - EP Toxicity:</u>								
Mercury	3.0	0.2	NR	105	0.4	NR	122	1.0
<u>Sample #9 - EP Toxicity:</u>								
Mercury	<0.5	0.2	NR	125	0.4	NR	119	1.0
<u>Sample #10 - EP Toxicity:</u>								
Mercury	8.2	0.2	NR	80	0.4	NR	90	1.25

Table B-6 (Continued)

BDAI constituent	Original amount found (ug/l)	Sample result			Duplicate result			Accuracy- correction factor ^b
		Spike added (ug/l)	Spike result (ug/l)	Percent recovery ^a	Spike added (ug/l)	Spike result (ug/l)	Percent recovery ^a	
<u>Sample #11 - EP Toxicity:</u>								
Mercury	0.7	0.2	NR	106	0.4	NR	98	1.02
<u>Sample #12 - EP Toxicity:</u>								
Mercury	<0.5	0.2	NR	99	0.4	NR	101	1.01
<u>Sample #12 - TCLP:</u>								
Mercury	<0.5	0.2	NR	90	0.4	NR	99	1.11

NR = Not reported.

^aPercent recovery = [(spike result - original amount)/spike added].^bAccuracy-correction factor = 100/percent recovery (using the lowest percent recovery value).

Table B-7 Matrix Spike Recoveries for Treated Residual - Plant D

BDAT constituent	Original amount found (mg/kg)	Sample result			Accuracy- correction factor ^b
		Spike added (mg/kg)	Spike result (mg/kg)	Percent recovery ^a	
<u>Sample #11:</u>					
Mercury	4.0	0.4	NR	83	1.20
<u>Sample #19:</u>					
Mercury	2.0	0.4	NR	99	1.01
<u>Sample #22:</u>					
Mercury	1.8	0.4	NR	99	1.01

NR = Not reported.

^aPercent recovery = [(spike result - original amount)/spike added].^bAccuracy-correction factor = 100/percent recovery (using the lowest percent recovery value).

Reference: Occidental Chemical Corporation 1987b.

Table B-8 Matrix Spike Recoveries for Treated Nonwastewater EP Leachate - Plant D

BDAI constituent	Original amount found (ug/l)	Sample result			Duplicate result			Accuracy- correction factor ^b
		Spike added (ug/l)	Spike result (ug/l)	Percent recovery ^a	Spike added (ug/l)	Spike result (ug/l)	Percent recovery ^a	
<u>Sample Set #1:</u>								
Mercury	<2.0	0.2	NR	99	0.4	NR	93	1.08
<u>Sample Set #2:</u>								
Mercury	<2.0	0.2	NR	106	0.4	NR	93	1.08
<u>Sample Set #3:</u>								
Mercury	<5.0	0.2	NR	96	0.4	NR	100	1.04
<u>Sample Set #4:</u>								
Mercury	<5.0	0.2	NR	115	0.4	NR	98	1.02
<u>Sample Set #5:</u>								
Mercury	<5.0	0.2	NR	112	0.4	NR	104	1.0
<u>Sample Set #6:</u>								
Mercury	<5.0	0.2	NR	101	0.4	NR	102	1.0
<u>Sample Set #7:</u>								
Mercury	<5.0	0.2	NR	109	0.4	NR	103	1.0
<u>Sample Set #8:</u>								
Mercury	<5.0	0.2	NR	110	0.4	NR	101	1.0
<u>Sample Set #9:</u>								
Mercury	<5.0	0.2	NR	113	0.4	NR	101	1.0
<u>Sample Set #10:</u>								
Mercury	<5.0	0.2	NR	109	0.4	NR	103	1.0
<u>Sample Set #11:</u>								
Mercury	<5.0	0.2	NR	108	0.4	NR	101	1.0

Table B-8 (Continued)

EDAT constituent	Original amount found (ug/l)	Sample result			Duplicate result			Accuracy- correction factor ^a
		Spike added (ug/l)	Spike result (ug/l)	Percent recovery ^a	Spike added (ug/l)	Spike result (ug/l)	Percent recovery ^a	
<u>Sample Set #12:</u>								
Mercury	<5.0	0.2	NR	108	0.4	NR	102	1.0
<u>Sample Set #13:</u>								
Mercury	8.0	0.2	NR	93	0.4	NR	94	1.08
<u>Sample Set #14:</u>								
Mercury	6.3	0.2	NR	94	0.4	NR	97	1.06
<u>Sample Set #15:</u>								
Mercury	32	0.2	NR	92	0.4	NR	82	1.22
<u>Sample Set #16:</u>								
Mercury	8.0	0.2	NR	89	0.4	NR	87	1.15
<u>Sample Set #17:</u>								
Mercury	<2.0	0.2	NR	92	0.4	NR	97	1.09
<u>Sample Set #18:</u>								
Mercury	9.3	0.2	NR	94	0.4	NR	82	1.22
<u>Sample Set #19:</u>								
Mercury	13	0.2	NR	80	0.4	NR	81	1.25
<u>Sample Set #20:</u>								
Mercury	14	0.2	NR	83	0.4	NR	83	1.20
<u>Sample Set #21:</u>								
Mercury	0.8	0.2	NR	107	0.4	NR	109	1.0
<u>Sample Set #22:</u>								
Mercury	<0.5	0.2	NR	102	0.4	NR	102	1.0

Table B-8 (Continued)

BDAT constituent	Original amount found (ug/l)	Sample result			Duplicate result			Accuracy- correction factor ^b
		Spike added (ug/l)	Spike result (ug/l)	Percent recovery ^a	Spike added (ug/l)	Spike result (ug/l)	Percent recovery ^a	
<u>Sample Set #23:</u>								
Mercury	<0.5	0.2	NR	102	0.4	NR	104	1.0
<u>Sample Set #24:</u>								
Mercury	<0.5	0.2	NR	104	0.4	NR	108	1.0

NR = Not reported.

^aPercent recovery = [(spike result - original amount)/spike added].

^bAccuracy-correction factor = 100/percent recovery (using the lowest percent recovery value).

Reference: Occidental Chemical Corporation 1987b.

APPENDIX C

COMPARISON OF TCLP AND EP RESULTS FOR MERCURY IN K071

The Agency compared 24 pairs of K071 data consisting of analytical results for mercury in the leachate from the Toxicity Characteristic Leaching Procedure (TCLP) and the Extraction Procedure (EP).

The data pairs are as follows:

<u>TCLP leachate</u> <u>mercury concentration (mg/l)</u>	<u>EP leachate</u> <u>mercury concentration (mg/l)</u>
0.0053	0.053
0.026	0.035
0.017	0.042
0.0004	0.0036
0.0002	0.0002
0.0004	0.0002
0.0032	0.0037
<0.0002	0.0002
<0.0002	<0.0002
<0.0002	0.0006
<0.0002	<0.0002
0.0004	<0.0002
0.0006	<0.0002
0.276	0.823
0.270	0.817
0.270	0.737
0.125	0.100
0.0004	<0.0002
<0.0002	<0.0002
<0.0002	<0.0002
22.0	13.4
0.0016	0.0035
0.0023	0.0192
0.0680	0.0910

A statistical comparison of the TCLP data set with the EP data set using the analysis of variance test indicates that no statistically significant difference exists between the means of the two data sets. This

indifference implies that the TCLP and EP are equivalent in their measurement of mercury.

Calculations were performed using the logtransformed values of the data, which assumes that the data follow a lognormal distribution. The test results are provided below:

<u>Source</u>	<u>Degree of freedom</u>	<u>Sum of squares</u>	<u>Mean of squares</u>	<u>F ratio</u>	<u>Critical value</u>
Between sets	1	1.8598	1.8598	0.1638	4.02
Within set	46	522.3669	11.3558		
Total	47	524.2267			

(If the F ratio does not exceed the critical value, the data sets are considered equivalent.)

The t-test for paired data also confirms the conclusion of the analysis of variance test.